ECONOMIC AND SOCIAL COMMISSION FOR ASIA AND THE PACIFIC

UNITED NATIONS ENVIRONMENT PROGRAMME

PROBLEMS AND PROSPECTS OF DESERTIFICATION CONTROL IN THE ESCAP REGION

BANGKOK, THAILAND
APRIL 1983

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PROBLEMS AND PROSPECTS OF DESERTIFICATION CONTROL IN THE ESCAP REGION

PROCEEDINGS OF THE REGIONAL
TECHNICAL WORKSHOP TO CONSIDER
IMPLEMENTATION OF THE PLAN OF
ACTION TO COMBAT DESERTIFICATION
JODHPUR, INDIA, 20-23 OCTOBER 1981

BANGKOK, THAILAND
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FOREWORD

Desertification has always been one of the major environmental problems of the developing countries in Asia as well as Australia. According to a United Nations assessment, some 378 million people living in an area of about 21 million square kilometres are being threatened by the process of desertification in the ESCAP region. Of them, approximately 29 million over an area of around 4.3 million square kilometres are seriously affected.

To focus world attention on this serious problem, the United Nations Conference on Desertification was convened in 1977 and adopted a Plan of Action to Combat Desertification for promoting and catalysing concerted efforts to counter this disaster. Echoing the recommendations of the Conference, the United Nations General Assembly, in its resolution 32/172, requested the regional commissions to support national efforts and co-operate with governments in their plans to combat desertification. In response, ESCAP organized a Technical Workshop in October 1981 to consider the steps taken by the Governments of the region to implement the Plan of Action. This Workshop, held at the Central Arid Zone Research Institute of India at Jodhpur, was attended by experts from 11 member countries and representatives of four United Nations agencies.

After reviewing the problems, progress and prospects in combating desertification, the Workshop felt that the order of priorities of the Plan of Action should be rearranged so as to ensure more efficient use of resources while recommending a series of activities in research, monitoring, training and information for concerted action at the regional level. The Workshop revealed that the steps already undertaken to implement the Plan of Action were somewhat inadequate, primarily for the following reasons:

(a) Lack of an interdisciplinary approach in combating the desertification process

(b) Limited transfer of technology to the rural areas

(c) Shortage of technical manpower

(d) Inadequate public participation

The *Problems and Prospects of Desertification Control in the ESCAP Region* is essentially based on the proceedings of the Technical Workshop convened by ESCAP. I should like to express my gratitude to the Government of Australia for providing financial assistance for organizing the Workshop and to the Government of India for offering host facilities, without either of which it would have been difficult to organize the Workshop. I should also like to acknowledge the technical and financial support provided by UNEP for the publication of this document.

Finally, I should like to urge all concerned – individuals, government agencies and intergovernmental and non-governmental organizations – to join hands and work together in implementing the Plan of Action so as to improve the lot of millions of impoverished people affected by the menace of desertification in the ESCAP region. As for ESCAP, our effort at the regional level will continue, in close co-operation with UNEP and other relevant United Nations organizations, to assist the countries in overcoming the problems of desertification in general and those identified by the Workshop in particular.

S.A.M.S. Kibria
Executive Secretary

April 1983

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PART I

SUMMARY AND RECOMMENDATIONS

I. ORGANIZATION

The Economic and Social Commission for Asia and the Pacific (ESCAP), in co-operation with the Government of India, organized a Regional Technical Workshop to Consider the Implementation of the Plan of Action to Combat Desertification at the Central Arid Zone Research Institute (CAZRI) at Jodhpur, India, from 20 to 23 October 1981.

The Workshop was attended by representatives of the following countries: Afghanistan, Australia, Bangladesh, France, India, Indonesia, Iran, Nepal, Philippines, Thailand and Union of Soviet Socialist Republics. The following United Nations bodies and other organizations were represented: World Food Programme (WFP), United Nations Educational, Scientific and Cultural Organization (UNESCO), World Meteorological Organization (WMO), Press Foundation of Asia and South Asia Co-operative Environment Programme (SACEP). The following experts attended the Workshop in their individual capacity: Mr. Thane Riney (Australia), Mr. P.Y. Revillion (France), Mr. S.H. Rasul (India) and Mr. Brian Spooner (United States of America).

The Workshop unanimously elected Mr. O.P. Gautam (India) as Chairman, Mr. A. Motamed (Iran) and Mr. Achmad Indrawan Sulaeman (Indonesia) as Vice-Chairmen and Mr. Ed. B. Pantastico (Philippines) as Rapporteur.

II. OPENING CEREMONY

The Workshop was opened on 20 October 1981 by the Honourable Rao Birendra Singh, Indian Union Minister of Agriculture, Rural Reconstruction, Irrigation and Civil Supplies. Mr. Shri Charan Mathur, the Chief Minister of Rajasthan State, presided. The session was also attended by Mr. Poonam Chand Bishnoi, Speaker of the Legislative Assembly of Rajasthan State; Mr. Ahmed Bux Singhi, Deputy Speaker; Mr. Chandan Mal Baid, Finance Minister of the Rajasthan State Cabinet; Mr. Pars Ram Maderna, State Minister of Revenue; Ms. Kamala, State Minister of Agriculture; Mr. Narendra Singh Bhati, State Minister for Colonization; Mr. Govind Singh Gujjar, State Minister for Sheep and Wool, and Forests; Mr. B.D. Kalla, Deputy State Minister for Education; Mr. Khet Singh Rathore, Chief State Whip, and several members of the Indian Parliament and the Legislative Assembly of Rajasthan State.

In his address welcoming the participants, Mr. O.P. Gautam, Secretary of the Department of Agricultural Research and Education and Director-General of the Indian Council of Agricultural Research, said that the presence of a number of ministers and high-ranking officials at the opening session of the Workshop was a clear indication of the importance which the Government of India attached to problems of desertification. He pointed out that the inhabitants of the affected areas lived under the constant threat of destruction of their livelihood and faced the danger of being uprooted from their familiar environment. The Plan of Action drawn up by the United Nations Conference on Desertification represented the first serious effort on the part of the world community to understand the problems of desertification in their totality. India had been one of the first countries in the region to realize the need for systematic research to comprehend the processes of desertification; a desert afforestation station had been established in 1952 and CAZRI, one of the first discipline-based institutions in that field, had been founded in 1959. Several technologies had been developed since for the reclamation of saline and alkaline soils, enhancement of productivity and stabilization of eco-systems through afforestation, fuel- and shelter-belt plantations, grassland improvement and sand-dune stabilization.

In his message to the Workshop, the Executive Secretary of ESCAP pointed out that potentially productive land was constantly being lost because of improper land management practices, resulting in soil exhaustion, erosion, waterlogging and increase in soil salinity. Deforestation could also trigger off an energy problem of fuelwood shortage in the affected areas. Those hardships brought about a socio-economic situation that might perpetuate the general conditions of poverty which already existed in an acute form in the region. At a time when the demand for food was ever on the increase because of the growing population, the spread of desertification was nibbling away at valuable land and reducing its productivity in predominantly agricultural countries, where every acre of arable land was already under cultivation. Technological progress as well as socio-economic and legislative measures had important roles to play in launching a concerted attack on desertification. The major constraints to the implementation of the Plan of Action to Combat Desertification were identified as (a) a need to introduce technological innovation through integrated, interdisciplinary research, (b) inadequate efforts to transfer the available technology to the people concerned and (c) lack of high priority for desertification control programmes at the national level, as a result of conflicting demands and scarcity of resources. It was emphasized that governments must have the necessary political will to develop and implement desertification control programmes successfully.

Mr. Shri Shiv Charan Mathur emphasized that, as deserts encompassed about two thirds of the physical area of the State (200,000 sq km), measures against desertification would always form part of the State's development strategy. The recognition of the limits of eco-systems and discrimination between production strategies which exhausted the potential and others which were regenerative had to be built into planning and development efforts. Over-exploitation or mismanagement leading to deterioration in the productivity of land brought about a self-accelerating process, and man was then soon faced with the stark reality of a man-made desert. Anti-desertification measures had to take cognizance of the human environment, respect the value systems and life-styles of the desert residents and nomads and depend upon social consent, education and the establishment of a dialogue with the people. As the costs of desert area development were enormous, a simple financial cost-benefit analysis would place desert development schemes at a relatively low priority level in any development planning scheme. The Chief Minister, therefore, suggested that international agencies should earmark assistance for anti-desertification programmes, while taking cognizance of the face that many of the projects might give little or no financial return. It was pointed out that if the basic resources of the desert were properly developed, it could be made independent of imported resources, but for that purpose all desert development plans had to be linked with, and supported by, larger national and international outlays and market policies.

The Honourable Rao Birendra Singh quoted several examples from history of rural people acting appropriately to prevent wanton destruction of the environment and the cutting down of trees, to show that, historically, man had lived in communion with nature in the country. Today, with the vagaries of the climate, erratic rainfall, increasing pressures by human and livestock populations and the resultant degradation of the environment, deserts and arid zones constituted about 12 per cent of the geographical land area of India, and 58 per cent of the western parts of Rajasthan State were under sand dunes. Indian deserts were perhaps the most thickly populated in the world, with an average of 61 persons per sq km, as against 3 persons per sq km in most other desert areas. The Desert Development Board had been established to plan and review the desert development programmes and a number of research institutions and departments were currently operating to look specifically into the problems of desertification. Operational research projects had been initiated to carry out constraint analyses, i.e. to identify technological, economic or sociological constraints to the transfer of technology. In accordance with the poverty eradication programme of the Government of India aimed at lifting the poorest of the poor above the poverty line through rural and agricultural development programmes with employment-generation potential, the Minister emphasized that the programmes dealing with the arrest of desertification processes and reclamation of affected areas should receive the highest priority in the country's development plans, as that alone would help the target groups struggling for existence under conditions of aridity, soil infertility and water scarcity. He concluded his address with an appeal for increased international monetary assistance to implement the country's desert development projects.

III. RECOMMENDATIONS

Despite the obvious achievements in the implementation of the Plan of Action over the four years since its adoption, progress towards the targets set for the years 1984 and 2000 had been slow. There was a growing feeling, reflected at the Workshop in both the opening addresses and the general discussions, that progress might be accelerated by a certain rearrangement of priorities in order to facilitate more efficient use of resources. The following recommendations, therefore, constituted reformulations of ideas and intentions which had been clearly stated in the Plan of Action but which had not yet inspired the necessary action.

The Workshop recommended:

I. Further technical research

Diagnosis

(1) In accordance with the findings of the inter-agency working group on desertification and the analysis of the country reports as summarized in the message from the Executive Secretary of ESCAP, appropriate programmes of survey and research should be initiated at both the national and the regional levels, as appropriate, in order to continue to increase knowledge of the nature and extent of desertification processes in the region.

(2) In the formulation of research projects, careful attention should be given to:

(i) The history of the interaction of human activities and natural processes that had led to the situation under study.

(ii) Provision for the communication of meaningful results to the people whose interests were threatened by the problem under study.

Prescription

(3) When the results of a project were formulated in terms of a prescription for action, such a prescription should be based on explicit evaluation of the conflicting as well as overlapping or common interests and views of local groups of people and the larger national interest.

(4) Prescription for corrective action should always be formulated to build (however selectively) on existing local ideas and customs, rather than to replace them with alien practices.

(5) Inasmuch as the particular desertification process which was most critical for the largest proportion of the population of the region was deforestation, countries should pay particular attention to the development of alternative energy sources, especially by village plantations of local species that would double as shelter belts and fuel reserves, and by other suitable means.

II. Monitoring

(6) ESCAP should create working groups of scientists and experts at the subregional and regional levels for the purpose of defining a monitoring system which would integrate all the available means of investigation, such as conventional ground surveys, integrated groundlevel monitoring studies, airborne and space-borne remote sensing and automatic data collection systems.

(7) ESCAP should strengthen its existing remote sensing regional project as a means of enabling member countries to apply the latest monitoring techniques for the continuous reassessment of desertification processes.

(8) ESCAP should request UNEP to assist in reviving the transnational monitoring project for South-West Asia.

III. Regional Centres

(9) ESCAP should prepare an inventory of institutions concerned with desertification control in the region, identify suitable training centres, such as CAZRI, and develop a regional training programme.

IV. Communication

(10) Bearing in mind the imperative need to increase public awareness of the dangers of desertification, ESCAP should develop means of harnessing all the available media in the region to that end, and in co-operation with other appropriate organizations, work to increase the flow of information both between scientists in different countries and between scientists, planners, politicians and the general public.

(11) ESCAP should undertake a review of the literature and other available information related to the processes, causes and effects of desertification in the region and should prepare practical manuals on selected specific problems, such as deforestation, shifting cultivation, soil conservation, shelter-belt establishment, sand-dune stabilization, overgrazing, waterlogging and salinity.

(12) There was an urgent need to set up and, if already in existence, to strengthen further, development planning machinery at the country level, in order to initiate and co-ordinate anti-desertification campaigns within each affected country. ESCAP should continue to play a leading role, in co-operation with other agencies, in initiating and/or strengthening the institutional and legislative framework for the successful implementation of the Plan of Action.

V. Co-ordination

The Workshop recognized the urgent need to co-ordinate anti-desertification activities and to make experience in that field cumulative. The need was obvious at both the national and the regional levels. The Workshop therefore recommended that:

(13) Countries which had not already done so, should consider setting up national committees on desertification at an appropriately high level so as to ensure coverage of all relevant programmes and the accumulation of relevant experience.

(14) ESCAP should encourage subregional groupings of countries with similar interests, which would allow them to pool their resources and make more efficient use of the possibilities of external aid. The Workshop recognized the importance of such environmental programmes as SACEP and the ASEAN Environment Programme in that context.

(15) Recognizing the already existing technology to combat desertification, ESCAP should set up machinery and act as a forum for effective exchange of that technology between member countries.

VI. Facilitation

The developing countries of the ESCAP region were urged to take advantage of the various types of specialized assistance that might be provided by the United Nations agencies:

(16) The developing countries of the region with desertification problems should take advantage of the assistance of WFP in an appropriate manner for acceleration of anti-desertification programmes towards their successful implementation.

(17) Recognizing that meteorological, hydrological and climatological factors played an important role in the processes of desertification, their assessment and control and weather- and water-monitoring stations should be established in the areas prone to desertification. WMO, through its technical commission, should conduct research on weather modification over desert-prone areas and on the role of atmospheric dust content on rainfall patterns in support of the efforts of the countries in the ESCAP region to combat desertification.

(18) The countries of the region should take advantage of the assistance in the struggle against desertification that might be offered by UNESCO through its MAB programme.

(19) In view of the need for financial and technical assistance in training programmes, developed countries were urged to consider the provision of financial assistance to such training programmes for developing countries, as appropriate, for further strengthening of national expertise in the region.

PART II

OPENING ADDRESSES

WELCOME ADDRESS
by
Dr. O.P. Gautam,
DG, ICAR

Honourable Union Minister for Agriculture, Rural Reconstruction,
Irrigation & Civil Supplies (Rao Birendra Singh ji),
Honourable Chief Minister of Rajasthan (Shri Shiv Charan ji Mathur),
Honourable Speaker of Rajasthan (Shri Poonam Chand ji Vishnoi),
Honourable Revenue Minister of Rajasthan (Shri Paras Ram ji Maderna),
Honourable Finance Minister of Rajasthan (Shri Chandan Mal Baid),
Honourable Chief Whip, Rajasthan (Shri Khet Singh Rathore)
Honourable Deputy Speaker of Rajasthan (Shri Ahmed Bux ji Singhi),
Honourable State Minister for Colonization (Shri Narendra Singh ji Bhati),
Honourable State Minister for Sheep, Wool and Forests (Shri Govind Singh ji Gujjar),
Honourable Dy. Minister of Education (Shri B.D. Kalla),
distinguished delegates, fellow scientists, members of the Press, ladies & gentlemen,

It is my privilege to extend to you on behalf of the Indian Council of Agricultural Research, the Central Arid Zone Research Institute and on my own behalf, a very warm and cordial welcome to this inaugural session of the ESCAP regional Workshop on the Implementation of the Plan of Action to Combat Desertification. Friends, you would agree with me that this is indeed a proud and historic day in the annals of the CAZRI, to have with us today the galaxy of such distinguished guests and participants, both national and international to grace this occasion. We are particularly grateful to the Union Minister for Agriculture and the Chief Minister of Rajasthan who, from their extremely busy schedules, have spared their valuable time to be with us. Presence of the Honourable Speaker and Deputy Speaker and the Minister of Agriculture and other Ministers at this occasion is the measure of deep interest of both the Government of India and the State Government of Rajasthan in problems of arid zones and the deserts.

We particularly extend our warm greetings to the delegates from other friendly countries and our esteemed guests from international supporting agencies who are present here today. In this connection, we are deeply appreciative of the decision of ESCAP to organise this regional workshop at Jodhpur which obviously is the most suitable place in this country for holding this workshop.

Sir, permit me to mention briefly the genesis and scope of this workshop. According to the United Nations estimates, about 378 million people are living in an area of 21 million sq. km. which is under the influence of desertification. They are living in constant danger of destruction of sources of livelihood due to the threats posed by growing desertification. They are facing the dangers of being uprooted from their familiar environments. Recognising the problems and in pursuance of the decision of the U.N. General Assembly taken in December 1974, a conference was held at Nairobi in 1977 to promote international action to combat desertification.

This conference formulated a 28 points comprehensive and co-ordinated global action plan to combat desertification by the end of the century. This action plan represents perhaps the first serious efforts on the part of the world community to understand the problem of desertification in its totality, and to take measures to combat desertification and developed desert areas and arid zones anywhere in the world.

The Conference adopted a very comprehensive and most appropriate definition of "desertification", namely the "diminution and destruction of the biological potential of land which can lead ultimately to desertic conditions". Thus the conditions such as soil salinity and alkalinity and soil erosion following indiscriminate deforestation are also covered under this concept of desertification. The Regional Workshop of ESCAP would review the implementation of the action plan recommended by the Nairobi Conference. Each country has contributed a country report and an overall status paper has also been prepared based on these individual contributions.

I may mention that India was one of the earliest nations to realize the need for systematic research to understand the processes of desertification and to develop technologies relevant under deserts conditions.

The Central Arid Zone Research Institute established in 1959 had impact since its beginning in the form of a desert afforestation station established in 1952. The CAZRI was one of the earliest discipline-based institutes. The emphasis was on inter-disciplinary approach and the divisions created in the institute were unconventional, such as the Division of Basic Resources Studies, Division of Biotic Factor Studies (Plant, Animal, Rodent and Human), Division of Energy Utilization, Division of Water Plant Relationship etc.

Through CAZRI and a number of other Institutes, such as the Central Sheep & Wool Research Institute, Avikanagar, the Central Soil Salinity Research Institute, the Indian Grassland & Fodder Research Institute, Jhansi and the Central Soil & Water Conservation Research & Training Institute, Dehradoon and the Dry Land Agriculture Co-ordinated Project, Hyderabad, the Indian Council of Agricultural Research (the Apex Research Co-ordinating body in India) has been playing a key role in studying the problems of desertification and in finding ways and means to control it. The Council has also helped establish three agricultural universities in the States of Rajasthan, Haryana and Gujrat, which also provide research and training support to programmes relating to Arid Zone Research. As a result of the research activities of these institutions, a number of technologies have evolved.

However, the challenge of desertification calls for a much greater effort, both nationally and internationally.

I wish to congratulate Dr. H.S. Mann, the present Director, for the fine leadership he has provided to the Institute for the past several years. Also, his team of scientists for their valuable contributions. The occasions have been developed for reclamation of saline and alkali soils, enhancement of productivity and stabilisation of eco-systems. Most of these technologies have already been adopted by developmental agencies, such as afforestation, fuel and shelter-belt plantation, grassland improvement, and sand-dune stabilisation, etc. In order to accelerate the pace of transfer of technology programmes, ICAR has launched Operational Research Projects and Lab to Land Programmes. I hope the delegates will have time to visit some of the field demonstrations located near Jodhpur. The Country Report, circulated by India, would indicate a number of programmes, like the Drought-Prone Areas Programme (DPAP), Desert Development Programme (DDP), etc. are under implementation. A massive programme of irrigation under the Rajasthan Canal Project has also been launched to revegetate the desert.

I am also reminded of those who contributed towards the development of this Institute – the first Director, Dr. P.C. Raheja who together with the distinguished scientist, Dr. C. Christian of Australia, laid the early foundations and contributed substantially towards the growth and development of this great Institution.

With these introductory remarks, I once again express our gratitude to the Honourable Union Minister for Agriculture and Rural Reconstruction to have kindly agreed to be the Chief Guest, and the Chief Minister of Rajasthan to have agreed to preside over this function. I wish to place on record the massive support which ICAR and CAZRI have received from both the Government of India and the Government of Rajasthan in developing the various research training and transfer of technology programmes. And, once again I wish to thank the distinguished delegates and esteemed guests for their kind presence at this inaugural session.

MESSAGE FROM MR. S.A.M.S. KIBRIA, EXECUTIVE SECRETARY, ESCAP

Honourable Rao Birendra Singh, Distinguished Participants, Ladies and Gentlemen,

It is a great pleasure and honour for me to welcome this learned gathering of scientists who are meeting at Jodhpur to discuss measures to combat desertification, which is one of the most serious environmental problems confronting the ESCAP region. Unfortunately, it has not been possible for me to be present at this important meeting owing to other commitments. However, I should like to assure you of my full support in your deliberations, particularly in terms of implementing the recommendations of the meeting. With this end in view, allow me to share some of my thoughts on this important issue with you. I should like to focus my comments on the issues of socio-economic development and rural hardships that are linked with the problem of desertification and the points we should emphasize in contributing to efforts to grapple with the problem.

Desertification, a term which the technocrats have chosen to describe ecological deterioration of land resulting in reduced productivity, is caused by a number of climatological, physical and anthropogenic factors such as drought, overgrazing, salinization, waterlogging, alkalinization, denudation of forests and nomadic ways of life. The ecologists have been talking of the "march of the desert" and, undoubtedly, the total area of arid and semi-arid zones is on the increase. Potentially productive land is also lost because of improper land management practices resulting in soil exhaustion, erosion, waterlogging and increase in soil salinity. Yet another type of problem is deforestation, which is continuing at an alarming rate in many countries of the region. It has been predicted that if the present trend of forest denudation continues, the tropical forests of some of the countries of the region may become extinct before the turn of the century. This would trigger off an energy problem because of a severe shortage of fuelwood in the areas affected by deforestation.

According to the world map of desertification, some 378 million people in an area of about 2 million square kilometres are affected or likely to be threatened by desertification in the ESCAP region. Of these, some 4.3 million square kilometres of land are already severely affected, causing hardships to some 30 million people and scarcity of such daily necessities of life as food, fuelwood, water and fodder for livestock. These bring about a socio-economic situation that may perpetuate the general conditions of poverty already existing in an acute form in this region. As a consequence, the rural population, particularly the rural womenfolk, are the most affected as they have to travel farther to collect fuelwood and water, two precious commodities which are being made even rarer by the spread of desertification. The effects could be particularly severe in many developing countries of the region where large proportions of the rural population live in conditions of absolute poverty. The figures also indicate that in terms of both population and area, the ESCAP region is the worst affected by desertification, compared with all other regions. It is therefore imperative that the problem of desertification in the ESCAP region be tackled on a priority basis in order to alleviate the socio-economic conditions of the people affected and ameliorate their insecure state of existence.

The population of the ESCAP region in 1977 was 2,290 million and it is estimated that this will increase to 3,590 million by the end of the century, an increase of almost 60 per cent. At a time when demand for food is ever on the increase in order to feed the growing population, the spread of desertification is nibbling away valuable land and reducing its productivity. This phenomenon is becoming very acute in most countries of the region, which are predominantly agricultural and where every acre of arable land is already under cultivation. The situation can only be remedied by adopting appropriate measures to combat and reverse the desertification process, in order to sustain the increasing population. Technological advancement as well as socio-economic and legislative measures have important roles to play in launching a concerted attack on this environmental scource; and I am sure that your deliberations at this meeting will make important contributions along these lines.

Recognizing the seriousness of the environmental problem and its impacts, the United Nations General Assembly adopted resolution 32/172, in which it requested the regional commissions, among other things, to assist the Governments in the implementation of the Plan of Action to Combat Desertification. Efforts to implement the Plan of Action were also supported at all the subsequent sessions of ESCAP, in view of its significance to the region as I have already mentioned. From a review of the country situations, it appears that the extent of the area affected by desertification and the technology for combating the process in some countries of the region, including Australia, China, India, Pakistan and the USSR, are well recognized. There has also been much progress recently in research and development on ways and means by which desertification could be controlled. The scientific work done at the Central Arid Zone Research Institute of India, where this Workshop is being held, gives evidence of this.

On the basis of the findings of the Interagency Working Group on Desertification as well as the regional overview paper prepared in connexion with this Workshop, there seem to be three major constraints to the implementation of the Plan of Action:

(a) Although there is a wealth of known technology in the area of desertification control, there is still a need to fill gaps in that knowledge and to introduce technological innovations through an integrated interdisciplinary approach, including the socio-cultural dimensions of the problems;

(b) Efforts to transfer available technology to the people who are effected by the desertification process are inadequate. Consequently, the developing countries in the region confronted by the problem are not able to take full advantage of even the existing scientific know-how and socio-economic insights; and

(c) Governments of countries faced with desertification problems appear unable, at present, to assign sufficiently high priority to desertification control programmes in the face of conflicting demands and scarcity of resources.

With regard to technological innovations, I am sure the deliberations of this Workshop and the follow-up of its recommendations will be of significance to all of us. However, the other constraints concern me more as they require the attention of the Governments at the policy-making level. Governments must have the necessary political will to develop and implement desertification control programmes successfully. It is rather discouraging to note that four years have elapsed since the Plan of Action was unanimously adopted by all the countries affected by desertification and, yet, land degradation due to soil erosion, deforestation, waterlogging and salinity continues unabated. All of us here, and particularly the developing countries of the region, are fully aware of the conflicting demands and scarce financial resources. However, I am sure you will all agree with me that there is no dearth of human resources in this region and that mobilization of human resources is a pre-condition for development of any sort. In his report on "The United Nations Development Decade: Proposals for Action", the former Secretary-General of the United Nations, U Thant, very rightly stated: ". . . educated and trained people are always the chief, and in the longer run the only, agents of development . . . The unutilized talents of people constitute the chief present waste, and the chief future hope of the developing countries."

This once again highlights the very important and basic need to ensure involvement and participation of the people who are affected by the process in all desertification-control programmes. After all, the basic objective of the desertification-control programme, or of any development programme for that matter, is the improvement of the quality of life and satisfaction of the basic human needs and aspirations of the people.

The challenges and tasks facing us in the matter are truly complex, difficult and wide-ranging. Such challenges can be met only if all of us join together in a concerted and determined effort with a clear and full recognition of the seriousness and magnitude of the problem. ESCAP, for its part, is fully prepared to play its role in this field within the broad framework of its mandates of social and economic development and, in this connexion, I shall be looking forward to your recommendations for further action at both the national and the regional levels to tackle such an environmental problem of paramount importance to all of us.

Last but not the least, I should like to convey my sincerest thanks to the Government of India and its people for providing host facilities for the Workshop at the Central Arid Zone Research Institute, which is not only located in the middle of the Indian desert but is also regarded as a centre of excellence for research and development in the field of desertification in the ESCAP region.

I wish you every success in your deliberations.

CHAIRMAN'S REMARKS
by
Honorable Shri Shiv Charan Mathur Chief Minister of Rajasthan

It is my pleasant duty to extend a hearty welcome to all the delegates and guests to this workshop. It was a happy idea to hold this workshop at Jodhpur where the desert is near at hand and cannot be wished away. It is encouraging to meet others of this region, who face, as we do, the problem of the desert. It inculcates a feeling of solidarity that we are not alone struggling with the long and difficult task.

Desertification is an aspect of the widespread deterioration of eco-systems which diminish or destroy the biological potential of land. It is a process which is the opposite of planned development. The developing countries have unavoidably to be engaged in a quest of ever greater productivity. This need not necessarily lead to the deterioration or over-exploitation of our resources. I would like to emphasise that measures against desertification will always be part and parcel of our total development strategy. The recognition of the limits of the eco-systems, and discrimination between production strategies which exhaust the potential, and others which are regenerative, have to be built into the planning and development effort.

Humanity has long been aware that considerable effort is required to increase productivity of land; it is a new awareness that even greater effort is required to stop the deterioration in productivity of land. Environment cannot be taken for granted. It can be improved but often it deteriorates if we act without awareness or responsibility. This is true for all eco-systems, but arid zones are particularly fragile eco-systems. Irregular and low rainfall coupled with rising population both human and cattle, easily leads to over-exploitation. This gives rise to degradation of vegetation, soil and water – the three elements which provide the natural foundation of human existence. The process of deterioration is a self-accelerating one. The rehabilitation costs rise rapidly, and after a time, for all practical purposes, we are faced with the stark reality of a man-made desert.

In Rajasthan, we have an arid zone of about 200,000 sq. km. It encompasses about three-fifths of the physical area of the State. I wish to highlight what, in our experience, have been the chief problems in controlling desertification and developing the desert areas.

The desert, or rather areas vulnerable to becoming desert, are not empty lands. They are populated by human societies which have their own cultures and needs. Desert development programmes cannot be taken up and completed in isolation. Anti-desertification measures have to take cognizance of the human environment. Anti-desertification measures have to enter the value systems and style of life of these residents and nomads. This is necessarily a slow process and we have made only a beginning here. These tasks are much more difficult to implement than construction of roads or dams or power houses. A successful pasture development project depends upon social consent, education and establishing a dialogue with the people. Plants and trees can be preserved if there is an awareness to protect and nurture them. This process is long and slow, but essential.

The cost of desert area development is enormous. Resources for desert development have to be pooled on a national, even international basis. When a developing country allocates its meagre resources, a simple financial cost-benefit analysis will drop desert development schemes to a relatively low priority. It is a regressive situation. A poor country faced with a desert problem will not be in position to single-handedly undertake effective desert development programmes. Programmes to combat desertification require international assistance – that too soft assistance for significant projects to yield results.

Our experience of seeking assistance form international agencies like IBRD shows that their lending still largely follows considerations of adequate financial returns. There is no specific allocation of loan funds for anti-desert projects. It is basically the same situation at the national level in plan formulation. Desert afforestation or pasture projects have an internal rate of return of 8 per cent as against a sizable number of irrigation projects having an IRR of 34 per cent to cover the loan folio. Again the international agency does not often take sufficient cognizance of the first point I made, that is, the culture of the society which inhabits the desert. A loan for range management may be more productive if given to an individual farmer with a large stock of sheep and having a sizable fenced pasture. This may be the model in developed countries, but a developing country is likely to prefer proposals for development of community or village pastures, rather than individual-oriented loaning schemes. The reality is problematic and difficult and we cannot make it vanish for the convenience of financing agencies.

Here I would like to touch upon another aspect of international assistance. Money alone will not be able to deliver the goods. There is a great deal of lag in technological know-how between developed and developing countries. At times, there is no readily available technology applicable to the peculiar scenario of the developing countries. Hence there is substantial and urgent need to have international co-operation on research and development with a view to developing what is not in terms of new technologies. Research and Development is a costly proposition. Developing nations are not in a position to set apart required funds for this. The international pooling of resources becomes more important in this context.

I have, therefore, to suggest that there should be earmarking of assistance from the international agencies for anti-desertification programmes and they should take cognizance of the fact that many of these may be low- or even no-return schemes and their implementation would involve sustained labour and time.

We all recognize the great advance that the scientists have made in finding solutions to combat problems of the desert. On the other hand, it will be recognized that we have yet to achieve a breakthrough in some areas which are crucial for desert reclamation and development. The basic resources of the desert which, if properly developed, can make it independent of imported resources; these are solar and wind energy and biogas. If in Rajasthan we could have economic generation of solar energy we could lift the water of Rajasthan Canal and spread it over the desert and the quality of life in the remotest hamlets could be improved. The same holds good for wind energy which could be harnessed to lift water from tubewells. The investment required for quick and effective development of solar energy and wind energy is of a high order. Appropriate technology has also to be fully developed to suit local conditions. Here also international co-operation requires to be promoted in order that the substantial scientific talent available in India is channelised to yield quicker economic results.

For the desert regions, the Dairy Development Scheme and development of wool and mutton marketing are important. In Rajasthan, we have been successful in developing a dairy infrastructure in the areas vulnerable to desertification. The success of these schemes depends on proper pricing and marketing and ultimately on national economic and commodity pricing policies. For instance, milk from the desert will be cow milk which will not get its due price if valuation is on basis of fat content. This milk is distant from the metropolitan markets and would bear a higher cost of transport. If the metropolitan market does not allow for these costs, the Dairy Scheme cannot be continued in the desert. Similarly, in India, prices of mutton are low when compared with international prices. This is because mutton has been supplied by nomadic sheep and goats raised at negligible cost. If you stabilise nomads and have regular pastures, the mutton costs will rise. While the problem of price rise for the metropolitan consumer is appreciated, our economic system will have to allow for conditions in which such desert development programmes yielding economic returns for those involved can be implemented. I mention these examples of milk and mutton to emphasise that Desert Development Plans have to be linked and supported by larger national and international outlays and market policies.

All of you are aware of the Rajasthan Canal Project which is one of our greatest development ventures. I certainly wish that at least some of you would be able to avail yourselves of this opportunity to visit it. Here, we are conveying 8 million acre feet of water from the rivers up north. If the canal flow is to follow the gravity gradient, we will develop a commond area of about 1.3 million hectares in the north of the State. The socio-economic situation in the Rajasthan Canal area should be studied by all persons interested in desert development. It is at once the planners' dream and his nightmare. We witness here colonization at a vast scale, movement of populations, development of new economic centres and towns, irrigated agriculture, change in land use, the contrasting profiles of this rich irrigated area and the rest of the desert rigours. We stand at a stage where it is possible to intervene and avoid blunders of mis-direction by taking cognizance of them beforehand. Suggestions can be made to maximize benefits, or quicken the development process. We would be very interested to learn from the experience of other countries touching on problems that we face in the implementation of the Rajasthan Canal Project and on desert development programmes.

Before I close I would like to dwell upon the point of predetermined notions about development and its various processes. In Rajasthan, we have been attempting to make and implement projects for the Lathi series or development of pasture on the left bank of Rajasthan Canal or for promoting mixed farming in tubewell commands in desert areas. While a learned audience unanimously condemns the plough as creating desert, it is easily convinced about the higher returns of growing fodder and keeping animals or giving up nomadism and developing pastures – it has been our experience that it is not obvious to the persons affected and persuasion is a difficult task. Secondly, I am not even sure whether the plough is all that bad. If water is available for irrigation, the plough can turn the desert into a granary. See what is happening in Ganga nagar? Hence there is the need to appreciate local context peculiar to the point of our reference.

To sum up, projects to combat desertification require large financial outlays which are not easily available in developing countries. Greater progress in implementing the Plan of Action requires enhancement of international assistance which must be earmarked for this purpose. Apart from the requirement of finance, it has to be noted that desert development projects are difficult to implement as they require change in the life styles of people. Extension work is difficult anywhere, but more so in desert tracts. Greater attention needs to be paid to achieve a breakthrough in the utilisation of the potential resources available in the desert including solar and wind energy and the valuable cattle wealth. Desert productivity can increase if there is a technological breakthrough in related spheres and national and international assistance is readily forthcoming.

Planning and implementation of Desert Development is a multi-dimensional exercise and requires the active involvement and co-operation of a multitude of disciplines and agencies. In that context workshops like the present one have a very useful and constructive role to play. We indeed have much to share in experience with each other.

I wish you all success in your deliberations which I am confident will be very constructive and fruitful.

INAUGURAL ADDRESS
by
Honourable Rao Birendra Singh,
Minister of Agriculture, Rural Reconstruction,
Irrigation and Civil Supplies, Government of India

Honourable Chief Minister of Rajasthan,
Distinguished Delegates, Ladies and Gentlemen,

I am indeed very happy to be with you and participate in the inaugural session of the ESCAP Workshop on Implementation of Plan of Action to Combat Desertification, which was formulated at the United Nations Conference on Desertification held at Nairobi during 1977. On this occasion, I extend to you, distinguished delegates, a very warm welcome to India and to the Central Arid Zone Research Institute (CAZRI), Jodhpur. This, as you perhaps know, is one of the national-level research institutes of the Indian Council of Agricultural Research, devoted primarily to research on arid zone and desertification problems. CAZRI was, therefore, the most suitable venue for this workshop. I hope your stay at Jodhpur will be comfortable and your workshop deliberations fruitful.

Hot deserts and arid zone of India constitute about 12 per cent of the geographical land area. Ninety per cent of these deserts lie in the States of Rajasthan (61 per cent), Gujarat (20 per cent), Punjab and Haryana (9 per cent). The average annual rainfall in this north-western arid zone varies from 100 mm to 450 mm and temperature from 45° C in summer to 6° C in winter. Aridity, thus, puts a severe limit on all biological productivity.

Indian deserts are perhaps the most thickly populated in the world with an average of 61 persons per sq. km. as against 3 persons per sq. km. in most other desert areas. The livestock population has practically doubled during the decade ending 1971. Due to high livestock pressure, there is over-exploitation of vegetation, and in drought years – when there is scarcity of even drinking water in parts of Rajasthan – man, cattle and sheep are forced to migrate to more hospitable areas and lead a nomadic life.

About 45 per cent of the arid areas are arable and only 5.1 per cent area is under forests. Barren and cultivable waste lands account for 27 per cent area. In western Rajasthan, as much as 58 per cent area is under sand dunes.

It is obvious that with vagaries of climate, erratic rainfall and increasing pressure of human and livestock populations, the problems of arid deserts are getting more difficult with deteriorating desert environment and diminution of the biological potential of the desert lands.

India can claim to be one of the very few countries to develop awareness of the problems of desertification. As early as 1952, the Government established a Desert Afforestation Station at Jodhpur which was renamed later in 1957 as 'Desert Afforestation and Soil Conservation Station'. In 1959, the Central Arid Zone Research Institute was established to conduct research on a multidisciplinary basis on problems relating to arid zone and desertic areas and included physical, biological and social sciences. Over the past 25 years, CAZRI has seen multi-faceted growth and development and has done creditable research work most relevant to arid zone agriculture and desert development. It has evolved and improved and given out technologies that form the basis for many on-going development programmes in this region. Starting with resource monitoring and resource utilisation research, CAZRI has developed technologies to control desertification and to use land and water resources more efficiently. The Institute has more recently taken up Operational Research Projects to carry out constraints analysis, i.e. to identify technological, economic or sociological constraints on transfer of technology. Based on the researches done at CAZRI during the last 25 years, ICAR has brought out the publication entitled "Desertification and its Control".

To start with, emphasis should be on qualitative and quantitative evaluation of desertification. Equal importance should be given to land-use planning and efficient water use. Adoption of management practices based on ecologically sound principles, economic feasibility, considerations of social acceptability, equity and wide public participation should be other elements of our desertification combat plan. Desert area problems would invariably require reclamation of degraded lands, introduction of suitable range land management and/or mixed farming systems with due emphasis on livestock, tree and grass components.

Low risk and low cost technologies are more relevant to the poor farmers of arid zones who suffer due to vagaries of weather more often than others. Likewise, watershed area approach would seem to be more appropriate for arid areas but here new approaches to promote group action will have to be developed. There is considerable scope for improving the efficiency of use of existing surface and ground water resources. I understand that rain water use efficiency is less than 50 per cent in some districts and existing land-use pattern utilised only 50 per cent of the rain on the average. There is thus considerable scope for proper management of rainwater.

Another area where research efforts would need to be stepped up would be the medium-term weather forecasting to provide an early warning system and to adopt contingency plans for the stress conditions expected. Also research needs to be intensified on selection and breeding of shrubs and trees for desert areas to fulfil the triple needs of fuel, fodder and fertiliser.

In appreciation of the development needs of desert areas, the Government of India and the State Governments have taken a number of steps. Desert Development Board was established in the 1960s to plan and review the desert research and development programmes. Drought Prone Area Programme (DPAP) represents another major effort at national level to help develop arid areas on priority basis. Problems of arid zones are the concern not only of CAZRI but also of the Indian Grassland and Fodder Research Institute (Jhansi), the Central Soil Salinity Research Institute (Karnal), the Central Sheep and Wool Research Institute (Avikanagar), the Dryland Agricultural Project (Hyderabad), and at least three State Agricultural Universities. Besides, the Zoological Survey of India, the Botanical Survey of India, the Geological Survey of India and the Meteorological Department have opened their regional stations specifically to serve the desert region. The State Governments have also launched extensive afforestation and grassland improvement programmes during the last three years and the Rajasthan Government has established a separate department exclusively for this work.

The need is to develop an integrated strategy to control population (both human and livestock) and accelerate the process of development through increased biological productivity and application of latest scientific technologies. New technologies should take into consideration not only physical and biological factors but also socio-economic needs. Along with improved technologies, we need to develop progressive public policies and development-oriented institutions to serve as vehicles of social change and economic advancement.

Desertification, as we know, is a complex problem that would require inter-disciplinary approach. It is also a self-accelerating process and, as it advances, the rehabilitation costs rise exponentially; hence the urgency to mount an all-out offensive to combat desertification. Such a frontal attack on this problem as well as the follow up action would require not only national but also regional and international collaboration. You may like to pay special attention to this aspect while reviewing the action plan.

The Government of India has pledged itself to lift, as early as possible, the poorest of the poor above the poverty line according to the poverty eradication programme of our Prime Minister. In this context, deliberations of this Conference to review the action taken on the Action Plan to Combat Desertification would be of great significance. Since most people in this region would fall within the target group – people who are struggling for existence under conditions of aridity, soil infertility and water scarcity – the Government of India has accorded highest priority to rural and agricultural development programmes with employment generation potential for such people. Therefore, programmes dealing with arrest of desertification processes and reclamation of affected areas should receive the highest priority in the country's development plans.

I am sure you would have in-depth discussions on these and other issues in the nature of research, training and development, and share your experiences with each other. I hope that you would come up with a modified plan of action in the light of your past experiences and that the new plan would be more amenable to implementation.

Before concluding, I would like to add a word of appreciation for the scientists and development workers who are engaged in this nation-building task of helping the weaker sections of our society to share the fruits of development, howsoever meagre and modest.

Once again, distinguished delegates, I wish you a very comfortable stay in India and very fruitful deliberations over the next four days. With this, I have great pleasure in inaugurating this ESCAP Workshop on the Plan of Action to Combat Desertification.

Thanks.

PART III

COUNTRY SITUATION

INTRODUCTION

The country papers* that follow were presented and discussed at the ESCAP Regional Technical Workshop to Consider the Implementation of the Plan of Action to Combat Desertification (PACD) which was held at Jodhpur, India, 20-23 October, 1981. It was the first regional workshop of its kind to be arranged by any regional commission of the United Nations in order to provide a post-UNCOD forum for the ESCAP member countries to exchange their respective experiences and expectations on the implementation of PACD and, at the same time, to interact among themselves as well as with representatives of the secretariat and some United Nations world agencies like UNESCO, UNEP, WFP and WHO.

In the country reports there is considerable variation in reporting the implementation of PACD and its format by individual countries. Statements by some delegates on the action taken with regard the individual recommendations of PACD were too brief, crisp and appeared 'official' rather than scientific or technical in nature. In a few cases, only general statements were made, without reference to the individual recommendations of PACD. It was, therefore, a rather difficult task to determine evenly and correlatively the various execution aspects of the corrective measures against desertification in the ESCAP region.

In addition, reports from only 11 out of 39 member and associate member countries of the region were discussed, and there are certain data and information gaps or occasional incoherence in some of them. Nevertheless the country papers as presented here are generally intrinsic and sagacious so far as their lateral and vertical presentations are concerned. The situations with regard the implementation status in those countries, which cite certain specific examples from case/pilot studies in support of their effort to combat desertification, are rather suitably represented and evidently expounded commensurate with the objectives of their endeavour. As far as possible conformal treatment and synthesis of the papers have been done within the limits of available records.

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* An overview of the country papers is under preparation and will be available in a separate ESCAP publication.

AFGHANISTAN

Progress Report on UNCOD Plan of Action to Combat Desertification

by

The State Planning Committee, Kabul

Introduction

The Government of the Democratic Republic of Afghanistan appreciates the generosity of the Government of India and the hospitality and effort of the Director-General of the Indian Council of Agricultural Research and the Director of the Central Arid Zone Research Institute and his staff, as well as the organizing and co-ordinating role of ESCAP and the overall planning of UNEP in making possible this Regional Workshop on desertification. Both the time and the venue are highly appropriate – the time in order to make sure we are on the right track to achieve implementation of the immediate measures required in the Plan of Action by 1984, and the place because of the regional and international stature of this Institute.

I hope that the intense interaction that these few days afford us will ensure the completion of those measures that are more or less on schedule and the timely and efficient redirection of various efforts that are not yet yielding the results we hoped for. Despite some unevenness in the achievements so far which I for one have to report, re-reading the Plan of Action in preparation for this occasion is an encouraging experience. The plan is comprehensive, well organized, balanced in its treatment of the range of relevant factors and issues, and clearly worded. The Desertification Unit, which took over form the UNCOD Secretariat and is responsible for the global facilitation and co-ordination of the Plan, should be congratulated on its form and presentation as well as the results of their efforts so far to bring it to fruition. It merits the full support of the world community, and a not insignificant result of this Workshop will be the reaffirmation of our combined commitment to co-operate in its timely implementations.

Policy

The main purpose of this meeting is to hear the progress made by each country of the region in the implementation of the Plan, to assess the state of the campaign and make proposals for the future.

The report from Afghanistan is mixed. The trends that were identified in our report to UNCOD were longstanding and no one expected that they could be turned around on a national scale in just four years. Moreover, Afghanistan is counted among the Least Developed Countries of the world, and it is certainly one of the most desertified among those of them represented here. Although there are no figures on the present state of desertification in Afghanistan that would demonstrate changes in the trends identified in the 1977 report, there is evidence that those trends continue – some of them have become more obvious and threatening. The effort required to turn them around is monumental. That effort must be partly technical and partly social – as is clearly foreseen in the Plan. Our achievements so far have been both technical and social.

The main thrust of our report is that we are taking care of the social aspects, but for further technical achievements we require much free access to the scientific and technological repertoire of the world community. On the social side – especially since our Revolution in April 1978 – we have been able to embark on a programme of radical reorganization which is directly aimed at the establishment of social equity that is considered necessary in the Plan. Our achievements so far are only a beginning, but are worth reporting because they demonstrate not simply the determination of the Government to fight desertification, but its commitment to integrate that fight with national reorganization and development and its desire to enhance its technical abilities by taking advantage of the various regional and international programmes that are available. The fight against desertification in the context of planned economic and social development is accorded the highest priority in government policy.

The Major Emphasis

In Afghanistan a number of technical projects have been begun or reinforced as a result of UNCOD, but they have often had poor results for reasons that are basically social and may be summarized as social inequity. Since technical progress alone in these conditions is insufficient, a major emphasis has been on promoting the social and legal context that would facilitate land use without desertification. Considerable attention is paid to the need for social reorganization in the Plan of Action especially in recommendations 12 and 13, but such reorganization, although the need for it is often acknowledged, is rarely given the necessary priority. The reason is not hard to find: reorganization threatens vested interests and is inherently difficult to carry through. It is inherently revolutionary – in thought, if not in action. Since the rate of social and economic change in Afghanistan continued to be relatively very slow, there was plenty of room for reorganization. The Revolution has finally made this reorganization possible. With particular regard to the relationship between people and natural resources the main points of this reorganization drive have been in the careful rewriting of laws.

Details

Progress against desertification in Afghanistan so far may be classified under three major headings: legal and political reorganization, national projects, and participation in regional programmes. Briefly, (1) the entire basis of the relationship between people and natural resources has been reorganized politically and rewritten legally. The new laws and associated regulations are now at various stages in the process of passing from initial draft to final implementation. Specifically, they deal with landholding, grazing, forests, hunting, public health, the organization and responsibilities of co-operatives, and the functions of the Ministries of Agriculture and Land Reform, Water and Power, and Public Health. (2) Comprehensive development projects with integral environmental components in accordance with recommendation No. 22 of the Plan of Action have been continued in the Helmand Valley, the province of Herat, and the forested areas of the south-east (though it has been necessary to discontinue these projects during the last two years for a number of reasons, including the lack of necessary foreign aid). The field investigations for a vegetation mapping project have been completed for an estimated 75 per cent of the country. In the vicinity of the capital, Kabul, high priority has been given to the creation of a green belt in order to combat the desertification caused by rapid urban growth. (3) Afghanistan has always been an eager participant in regional programmes, though as a Least Developed Country we are severely limited in our ability to contribute to such programmes and we are obliged often to request technological and financial assistance to enable us to benefit from them. We have participated as actively as possible – given the constraints of our resources and of international assistance – in the ESCAP Remote Sensing Regional Project (since 1972), the South-West Asia Transnational Monitoring Project (since 1976), the UNEP/USSR Project to Combat Desertification through Integrated Development (since 1978), and most recently the South Asia Co-operative Environment Programme (since 1980).

The remainder of this section lists briefly the activities relevant to each recommendation of the Plan of Action.

Recommendation 1

Assessment must be a continuing process. Large areas of Afghanistan have still not been properly assessed ecologically, and many assessments that have been made have yet to be translated into fully accessible form. Ecological assessment was an integral component of each of the national projects listed above that have had to be temporarily discontinued. These individual assessment activities are co-ordinated and enhanced by the work of the Institute of Cartography and Geodesy which has been considerably strengthened in recent years, especially in its mapping and remote sensing capabilities.

Recommendation 2

Ecologically and socially sound land-use planning is an integral component of our Revolution, and significant progress has been made in reorganizing the man/land relationship, though complete implementation will take time. Steps are also being taken to establish a high level National Committee on the Environment, on which all the government bodies that bear responsibility for some aspect of the environment will be represented, that will co-ordinate planning from the environmental point of view.

Recommendation 3

Public participation is a general principle of planning since the Revolution, and with regard to anti-desertification measures is implemented primarily through the new Co-operatives law.

Recommendation 5

In order to develop and improve the management of water resources, the Government of Afghanistan is participating fully in the programmes for the International Water Decade, and has established a National Policy Committee to co-ordinate activities. A new department of science and technology has been created in the State Planning Committee explicitly for the purpose of inter-relating the development of indigenous technologies with exogenous science and engineering and international technological assistance. In October 1981 a special exhibition was held in Kabul to publicize the activities of this department. Technologies for improving the efficiency of water use and conservation are a major emphasis of this programme.

Recommendation 6

The degradation of rangelands is the most serious form of desertification for the majority of the population of Afghanistan, and it was for this reason in particular that Afghanistan participated eagerly in the Transnational Project, for which a pilot project area was identified in 1977. A new grazing law has now been formulated and in the five-year plan there is a provision for the efficient organization and facilitation of the seasonal migration of pastoralists. Afghanistan is also interested under MAB projects 3 and 4 and EMASAR.

Recommendation 7

With regard to the deleterious effects of dry farming, legal limits to cultivation by tractor ploughing in marginal dry lands better suited for grazing are provided in the new landholding law. The revegetation of watersheds is presently receiving high priority in the immediate vicinity of Kabul.

Recommendation 8

The problems caused by waterlogging and salinization in the Helmand Valley have long received high priority in development planning. It is hoped that recent socio-economic changes will be beneficial but there is a desperate need for increased technological assistance.

Recommendation 9

Measures to promote soil conservation and to stabilize moving sands are undertaken mainly through individual projects of the Rural Development Department.

Recommendation 10

On the basis of a number of studies assisted by FAO new provisions have been made for the regulation of hunting and the management of wildlife and flora and fauna generally, including the establishment of national parks. The Ramsar and Washington Conventions have been signed and work has begun on a National Conservation Plan.

Recommendation 11

A full scale comprehensive monitoring project was envisaged under the Transnational Project.

Recommendations 12 and 13

The emphasis here has been on the development of new legislation especially for landholding and co-operatives.

Recommendation 14

A public health law is in preparation with the assistance of WHO.

Recommendation 15

This recommendation is covered in the legislation listed above.

Recommendation 16

See under Recommendation No. 11. The Transnational Project was designed to cover both the natural and the human conditions.

Recommendation 17

No progress has been made under this heading, except in the attempts to increase social security generally.

Recommendation 18

The new department of science and technology in the State Planning Committee is specifically concerned with this recommendation.

Recommendation 19

This recommendation concerns problems that are particularly serious in Afghanistan and among the most difficult to resolve. Some progress has been made in the propagation of fast-growing species by the Department of Forestry, but generally this is an area in which Afghanistan stands in particular need of external assistance. It is with this need in mind that Afghanistan has recently undertaken to discharge the responsibilities of "Focal Point in Social Forestry" under the South Asia Co-operative Environment Programme.

Recommendation 20

For the implementation of this recommendation the Government relies primarily on existing programmes of the Rural Development Department and the Co-operatives Organization.

Recommendation 21

A National Committee on Desertification was instituted in 1977 but lapsed as a result of the loss of momentum of the Transnational Project. In its place steps are now being taken to establish a National Committee on the Environment with more general responsibilities. Participation in regional programmes continues to be eagerly sought.

Recommendation 22

It is the policy of the Government of Afghanistan to combat desertification whenever possible by means of nationally co-ordinated comprehensive development programmes. It was with this aim in mind that the Government joined the UNEP/USSR Project to Combat Desertification through Integrated Development.

Expectations

This report of achievements would not be complete without more indication of context, in particular of the relationship between what has been achieved and what had been projected. There have been both triumphs and failures in the record of achievements, most of them because of our own domestic affairs, but some of them deriving from the opportunities offered by interntional programmes. Afghanistan has gained considerably from opportunities offered in particular by United Nations' programmes over the last decade, and in the following remarks we do not mean to belittle those gains.

UNCOD held out enormous hopes that "Desertification can be halted and ravaged land reclaimed in terms of what is known now. All that remains is the political will and determination to do it" (UNCOD Secretariat, Desertification: Causes and Consequences, Pergamon Press, 1977, para 61). For Afghanistan and three of its immediate neighbours the South-West Asia Transnational Monitoring Project was established, by UNCOD initiative, as the major channel of communication to enable us to profit from "what is know now". As events in this region progressed through 1978 and 1979 the Transnational Project was placed under the Global Environmental Monitoring System (GEMS) and redefined as a group of interrelated national projects. But it is now over two years that no communication relating to the project has been received in Afghanistan, despite the fact that during the last mission relating to the project in May-June 1979 Afghnistan expressed keen interest in developing its national component, given the necessary assistance. Afghanistan was in the process of organizing its national effort to combat desertification within the framework of the Transnational Project and expected that under Recommendation No. 4 of the Plan of Action UNEP would offer assistance through this framework. The Government of Afghanistan has the political will and determination to halt desertification which has been hampered by insufficient access to the necessary technical knowledge. We, therefore, would encourage our neighbours present at this meeting to press for the resuscitation of the Transnational Project. We are determined to make the most of such programmes, including – besides the Transnational Project – SACEP, the ESCAP Remote Sensing Regional Project, and the newly established international Institute for Research on Mountain Eco-systems in Nepal, in order to acquire the necessary technological assistance to complement the social and political measures we have been taking.

Needs

In order to develop fully and to implement a comprehensive national plan of action to combat desertification, Afghanistan stands in need of considerable technical assistance. We hope that we shall be able to satisfy some of this need through regional programmes, under ESCAP auspices, since these programmes offer us an access to institutions with relevant regional experience and expertise such as CAZRI, and the opportunity to enter into continuing discussion of mutual problems and obtain advice on important techniques, such as water harvesting, from people who have used these techniques in culturally similar, as well as ecologically similar, situations. But we also have needs which will probably force us to look beyond these programmes. In particular we need assistance in co-ordination on two levels. We need the full-time services of a general ecologist to advise us on the technical aspects of overall ecological planning, research and training. And we need the occasional services of a human ecologist to consult with us on the ecological aspects on development, legislation, and administration.

Conclusion

A report from a Least Developed Country is bound to be a plea for help. Afghanistan is aware of its strengths but is presently able to make scarcely any contribution from those strengths to work beyond its borders even, for example, in the secretariat of SACEP. This report, therefore, emphasises the weaknesses, but it also shows that despite the weaknesses much important work is being done. However, in order that this work will be successful in the long term we are in desperate need of certain types of assistance. We have identified some specific needs. We conclude by acknowledging the efforts of the Desertification Unit over the four years since UNCOD, as well as those of other United Nations' agencies, in relation to the desertification problem. The multiplicity and variety of these efforts sometimes present their own problems – of co-ordination, especially as they relate to a desertified and Least Developed Country. The task of co-ordination, as well as facilitation, falls on the already overfilled desks of the Desertification Unit. We should like, by emphasising our appreciation of their efforts so far, to encourage them to make even greater efforts in the future.

AUSTRALIA

Country Report

Report on the Implementation of the Plan of Action to Combat Desertification

Introduction

Australia does have desertification problems in parts of the arid zone of the continent. This is defined as the zone where rainfall is too low for crops or introduced pasture plants to be grown.

The arid zone covers 5.3 million sq. km. (70 per cent) of mainland Australia, 3.4m sq.km. are used for grazing about 25 per cent of Australia's sheep and cattle, and the remaining 1.9m sq.km. are unused crown land which is mostly desert or semi-desert. 1.8m sq.km. (55 per cent) of the area in use is estimated to require treatment for degraded vegetation and accompanying erosion, 0.7m sq.km. requiring better management practices only and 1.1m sq. km. requiring treatment by works (costing $65 million at 1975 prices) as well as better management practices.*

Range vegetation can be very slow to recover from degradation. Climatic conditions suitable for the re-establishment of plants are very infrequent, and seed supplies may be severely depleted. Arid zone programmes, therefore, must be long term.

Current better management treatments centre around appropriate land use, better control of livestock through the application of range management principles and use of fences and water supplies, and avoidance of overstocking.

Present arid zone treatment works and practices, including fencing, extra water supplies and pitting, are of high cost relative to the capital value and value of production per unit area. This means that studies aimed at finding lower cost treatment should be given high priority.

The inputs and destocking necessary to achieve conservation with a continuation of grazing on some arid zone land types may make that land use quite uneconomic. This leaves three options:

(i) allow grazing to proceed under free market forces with eventual desertification of some types of land;

(ii) public subsidy of a portion of the cost of conservation treatment; or

(iii) change of land use away from grazing, i.e. resumption of leases and compensation of owners.

Some difficult administrative and political decisions will be involved in selecting appropriate options. These decisions should be based on whole-property or regional socio-economic evaluations of land use and land management alternatives for each of the more extensive land types.

Two partially separate sets of factors are considered to be responsible for intensifying the natural processes which lead to desertification.

The first set comprises those factors directly responsible for overgrazing of the native vegetation. These include overstocking by sheep and cattle, overstocking by feral animals particularly the rabbit (see companion paper by O.B. Williams), land use inappropriate to the capabilities of the land,

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* *Source:* "A Basis for Soil Conservation Policy in Australia", Report 1. Commonwealth-States Collaborative Soil Conservation Study 1975-77: AGPS, Canberra, 1978.

and stock numbers not being reduced sufficiently in response to droughts. Ways of reducing the effects of these factors may be amenable to transfer between regions with similar soils, climate, topography and animals.

The second set comprises factors which operate through people – the social, traditional, political, and economic forces which shape land use and land management. These are not easy to identify or evaluate, and are likely to differ from region to region. Nevertheless, it is here that the major basic causes of desertification are to be found. These factors are thought to be quite significant in Australia, but have not been effectively analysed or countered. Australian experience here is not likely to be of much benefit to other countries as these factors and their operation are likely to be very different elsewhere.

Soil conservation and land administration in Australia are constitutionally State responsibilities. The Federal Government has interests in co-ordination, national welfare, and research (CSIRO), but one of its current policies ("new federalism") is to devolve all appropriate functions back to the State governments and State authorities.

This has been done with soil conservation. National studies and reports in 1970 and 1978 recommended that the Federal Government should accept a national role in soil conservation if land degradation in Australia were to be reduced. However, the Federal government decided in April 1981 that the proposed national soil conservation programme should be transferred to the States and the proposed funding be included in general grants to the States.

Implementation of Plan of Action in Australia.

Although there are numerous programmes, structures and policies in Australia which can be seen as implementing various aspects of recommendations of the Plan of Action to Combat Desertification, it should be recognised very clearly that nearly all of these have been initiated by governments and their public service authorities (largely State), some community organizations and some individuals, sometimes long before the U.N. Conference on Desertification in 1977, and have not been initiated as a consequence of that conference or in response to those recommendations.

This section describes programmes and arrangements, the majority of which are at the State level, which appear to satisfy various aspects of recommendations of the Plan of Action.

Recommendation 1

Australia has adequate national hydrological and meteorological monitoring networks,

newly established LANDSAT receiving station,

various organizations monitor seasonal conditions,

some desertification maps produced, eg. for world map, but mainly for regions within States,

no continuous monitoring system especially for desertification.

Recommendation 2

Most land evaluation and land-use planning carried out by State authorities and local governments in agriculturally productive and peri-urban areas; no national land-use planning group.

Surveys of natural resources initially done by national bodies (CSIRO, Divn. of National Mapping), but majority now done by State authorities.

A reasonable body of natural resource data exists at overview level, but more detail usually needed for land-use planning and management decisions.

Adequate land-use planning only carried out for limited areas, e.g. Western Division of NSW, Gascoyne catchment in WA, soil conservation group schemes in Qld, NSW and Vic.

Procedures for conducting and implementing land-use plans are generally available, but need to be known and used much more extensively.

Recommendation 3

Public awareness and participation are not well developed (desertification is not considered newsworthy by the media) and only isolated individuals and groups are aware and active.

There is no national programme to increase public awareness; some ecological groups are active over specific areas, e.g. Gordon River in Tasmania, and soil conservation authorities are active and effective in group scheme areas.

Recommendation 4

n.a.

Recommendation 5

Many aspects of this recommendation achieved by national water resources programme and Australian Water Resources Council; these were established prior to 1977.

Recommendation 6

Surveys of range condition only carried out in limited areas on an ad hoc basis.

Deferred or rotational grazing not practised widely or regularly, general practice is set stocking with some irregular spelling of pasture.

Research to develop improved grazing strategies and management is in progress in several places (note companion paper by O.B. Williams).

Programmes and research for stock improvement and disease control have been active for several decades.

Some of native fauna is protected, other species, e.g. kangaroos, may be taken during open seasons.

The Commonwealth and States co-operate in drought relief schemes through subsidised stock transport and loans, but this relief is usually provided after land degradation has occurred.

The economic basis of the pastoral industry is being strengthened through rural adjustment schemes, national or State marketing bodies, improved transport, and research and extension.

Land tenure administration is very conservative and slow to change; it generally favours the landholder through minimal regulation and restriction.

Recommendation 7

Some research aimed at improving cropping systems has existed over the past 30-40 years, at present there is extensive research at regional level by State authorities aimed at establishing viable systems of minimum tillage, conservation cropping, and opportunity cropping.

Limits to cultivation of marginal dry lands are mostly economic ones set by yields and costs, although in a few areas such as the Western Division of NSW there are legal restrictions on cultivation.

Strip cropping and shelter belts are used in some places in Qld, NSW and SA.

Revegetation or farm diversification are not practised except in a few isolated cases.

Land tenure systems generally do not encourage conservation agriculture, and change in this direction is slow.

There has been a substantial improvement over the last decade in the awareness by civil engineers of the need for conservation measures in civil works and in the incorporation of these measures in recent works.

Recommendation 8

Major problems of salinization of irrigated land, waterlogging and salinization of river water are becoming evident along the Murray River.

Engineering solutions are being attempted, e.g. improved drainage and salt leaching, interception and diversion of saline drainage water.

Solutions through improved water management, although potentially more effective, are lagging behind engineering solutions.

Some changes in cropping systems have been made to reduce water wastage.

New irrigation schemes generally take account of drainage needs, salinisation, and soil properties; environmental impact statements are usually required.

Recommendation 9

Steps are being taken in most cases to stabilise and revegetate lands degraded by mining, industry, tourism or other non-agricultural activities, e.g. dust control programmes at Broken Hill and Alice Springs, protection of vegetation at Ayers Rock, rehabilitation programme at Ranger uranium mine.

Indiscriminate use of all-terrain vehicles has caused land degradation in numerous local areas, legislation for their control in these areas has been enacted in the NT, and local governments may exercise some control.

Recommendation 10

Commercial exploitation of native animals is restricted by legislation and regulation in all states, rare species are closely protected, and even common species like kangaroos are exploited only during prescribed open seasons.

Vegetation is grazed on pastoral land without specific restriction, but the taking of native flowers and rare species is generally prohibited except with permission from State authorities.

Recommendation 11

There are national systems in Australia for monitoring climate (Bureau of Meteorology), and hydrology (Australian Water Resources Council and State authorities), but not for ecological monitoring of land, plants or animals.

Recommendation 12

No substantial analysis or evaluation has ever been attempted of social, economic and political factors bearing on desertification in Australia. The importance of these factors is recognised by some people, and such an evaluation will be necessary if sound decisions are to be made on land use in the arid zone.

Recommendation 13

The rural population of Australia's arid zone is very small and static or declining.

Government policy has been to provide and subsidise communications (radio, telephone, TV), transport (air, roads), education and medical services for these people.

Recommendation 14

The flying doctor network and associated radio network have provided health services for many years to people living in isolated parts of the arid zone.

Recommendation 15

National land use planning and the preservation of good agricultural or pastoral land for those uses are often the subjects of discussion but have not been put into practice in Australia.

Land-use planning is done at local urban and peri-urban levels by local governments.

Housing design and energy supply for isolated arid zone areas have been the subject of some research and development, some results are evaporative cooling, solar hot water, and solar panels for providing electricity for communications relay stations.

Recommendation 16

Monitoring of "human condition" is done through national censuses held every five years, and through annual, quarterly or monthly information gathered by the Australian Bureau of Statistics.

Recommendation 17

In the case of a major disaster such as drought, national disaster relief arrangements exist, run by the State and Commonwealth governments, each State meeting its own cost up to a predetermined base – after which the Commonwealth contributes at $3 for every $1 of State expenditure.

Benefits comprise loans for feeding and restocking, and transport subsidies for livestock.

A drought-bond scheme exists whereby a landholder can put aside untaxed profits, receive a reasonable interest rate on them, and withdraw them when needed in times of drought.

Some landholders maintain reserves of grain or fodder for drought feeding. However, this practice is marginally economic.

Drought insurance schemes are discussed but not implemented.

Stock in drought affected areas may be sold, retained and hand fed, or agisted elsewhere in areas not affected by drought.

Recommendation 18

Australia's capabilities in science and technology related to desertification are probably adequate, the main problems lie in making full use of them and in their applicability and transfer to other areas.

Recommendation 19

Solar water heaters, evaporative coolers, windmills for pumping water, and wind generators for electricity are manufactured in Australia.

Some overseas project assistance in reforestation is being provided, e.g. in Nepal.

Recommendation 20

There are facilities and expertise in Australia to provide training related to desertification but most of the training, education and information related to desertification must be developed and spread locally in the countries at risk.

Recommendation 21

There is no co-ordinated national machinery in Australia specifically for combating desertification; the Standing Committee on Soil Conservation (a committee of the Australian Agricultural Council) partly fills a co-ordinating role, but other functions relating to various aspects of desertification are spread among at least six other Commonwealth/State ministerial councils and their committees.

Desertification, along with soil conservation, is constitutionally a State responsibility in Australia; the policy of the present Federal Government is to devolve such responsibilities back to the States.

Recommendation 22

Assistance in the form of technical expertise is available from Australia.

Australia has also assisted with funds for some projects in other countries, e.g. Somalia, and ESCAP Workshop in Jodhpur.

Recommendations 23 to 28

n.a.

ANNEX

Practical Experience in Combating Desertification

by

O.B. Williams*

Desertification in pastoral (non-arable) regions of Australia is expressed in three ways, two categories which can be seen easily and a third which is difficult to discern and which is difficult to demonstrate. First is soil erosion, either non-reversible or possible to ameliorate; second is pasture deterioration, either non-reversible or reversible; third is soil fertility run-down or change in soil physical condition, but without soil erosion.

The factor of prime importance in desertification is the grazing animal which can be the usual sheep or cattle, but can also be the introduced European rabbit. Drought is of much less importance in our view; it sets the seal on what would happen inevitably. Runs of favourable seasons are responsible for plagues of rabbits and the build-up of flocks and herds; population explosions of desirable plant species, as well as some weedy species, are favoured also by these seasons.

Specific examples of practical experience in combating desertification to be described briefly involve the rabbit, which, unlike sheep and cattle, is difficult to control, and the utility of the demographic information gathered for key perennial shrubs and grasses.

In a recent study of rabbit plagues on a property in South Australia the plague years were given as 1931, 1937-8, 1947-8, 1951-2, 1955-6, 1970 and 1973-4. These were years of good rainfall. In the 1974 plague there were estimates, based on capture-recapture techniques, suggesting that 3,500 rabbits/sq. km. were present and after the population crash in the succeeding dry season some 2,300 dead rabbits/sq.km. were estimated. The long-term cattle carrying capacity is 1 beast/2-3 sq.km.. Between the plagues the rabbit population is at a much lower level, however, seedling plants that establish in the same favourable season, and mature plants from earlier populations are severely damaged or eliminated. The regular (mostly annual) rabbit eradication measures commenced in the long-term Koonamore Vegetation Reserve have shown that regeneration of shrubs such as mulga (*Acacia aneura*) was prevented before the control programme by the small resident rabbit population in a part of the exclosure favourable for warren development; successful establishment of mulga occurred in the very wet summer of 1973-4.

In western New South Wales a population study of black bluebush (*Maireana pyramidata*) has shown that its recruitment occurred in a favourable season in the presence of rabbits, but that the survivorship curves were stepped, each downward step representing losses due to rabbit attack in dry spells when the annual herbs favoured by rabbits had dried. The survivorship curves of plants in the adjacent exclosure did not show these losses and both the number of black bluebush and the life span of the cohort (age-group) would exceed that of the grazed plants.

Studies of other species of perennial shrubs show that recruitment occurs more frequently than had been supposed, but that few plants survive in the presence of rabbits. An elaborate study using lucerne (alfalfa) pellets to simulate a desirable species in a large paddock (4050 ha) with 900 Merino sheep and abundant natural forage has shown that the paddock was thoroughly explored, even at this low stocking rate, and one can infer that in time a population of a desirable plant could be extinguished. In summary, Australian experience shows that rabbits must be controlled and sheep must be managed if the trend to desertification as indicated by the population trend of desirable perennial shrubs is to be halted or reversed. For more than 90 years the pastoral industry has fought

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the rabbit with capital, labour and available technology. In retrospect the widespread ignorance of the ecology of the rabbit has been the major (and crucial) deficiency.

Recent studies of rabbit populations at selected sites (habitats) in a number of contrasting regions over periods of both abundant rainfall and drought have led to the conclusion that in all regions studied, some habitats remain favourable for rabbits at all times; these habitats are essential for the continued survival of the rabbit populations. Further, these habitats were found to be limited in extent and readily defined. The most favourable habitats for survival were those near large swamps which collected water from the surrounding slopes by run-off; predation by foxes and feral cats was heavy at these sites. Stony areas with large, deep warrens and proximate to drainage lines were less favourable as drought refuges, but predation was less severe and out-migration after drought possibly led to the re-colonizing of other habitats. Dunes and sandy loams, the sites of plague numbers, were the least favourable drought habitats.

The investigators concluded that "rabbits in the arid zone could probably be controlled by destroying those warrens which lie close to the large swamps and major drainage channels in all habitats, including man-made watering points", with the advice that "stony warrens can be destroyed regardless of season; but warrens in sandy habitats should be destroyed only in summer or after long dry periods".

Practical measures to combat what is seen now as the No. 1 agent for desertification in shrub lands have been devised by the Western Lands Commission of New South Wales. This scheme recognizes the fact that pastoralists are unlikely to have funds available for the destruction of rabbit warrens in drought, and seldom have the heavy mechanical equipment needed to destroy warrens, particularly those in stony landscapes. The pin-pointing of favourable over-drought habitats using aerial survey, a small equipment pool of heavy machinery and skilled operators, and the incorporation of the pastoralist into the labour/wage structure of the team, should he so choose, are ingredients of the scheme.

Practical measures to combat desertification at the level of plant communities (rangelands or grazing lands) have met with limited success, in spite of attempts by pastoralists and rangeland investigators over many decades; success has been restricted to the introduction of buffel grass (*Cenchrus ciliaris*) into the northern (summer rainfall) region, pitting and water ponding techniques at a few sites, and several cases of vegetation improvement following long-term (10 years) exclusion of the grazing animal after some 80 years of heavy use.

Although research projects continue to use treatments such as fire and grazing, current experiments and previous studies for which information is available are now being subjected to time-course analysis of individual plants of important species (i.e. population biology or plant demography) in a manner similar to that used in the rabbit habitat study; the investigation of black bluebush populations described earlier is such a study. Generalizations which may be of importance in terms of practical application to desertification problems follow.

Favourable rainfall seasons, or sequences, can produce plant population explosions; the species so recruited may be a weed or a valuable forage species. Because a century of grazing by large herds and flocks of hooved European domestic livestock replaced millenia of lax grazing by soft-footed marsupials, there can be substantial soil changes and present-day soils need not be the appropriate media for recruitment of perennial species still present as 'mature' individuals. Exposed B horizons of former complete duplex soils favour woody shrub dominance rather than the grass dominant ground layer characteristic of the original savanna. Studies suggest that large cohorts are long-lived and small cohorts are short-lived; this is possibly a function of excellent germination and establishment conditions. Further, management in the early establishment phase can decrease or increase the initial mortality and so increase or decrease the life-span of the cohort; appropriate management can result in a small cohort being long-lived and *vice versa*, suggesting a role for management in the encouragement of desirable plants and control of undesirable plants.

The intervals between substantial recruitment events can be longer than the life-span of cohorts (40 years as against 20 years) and the presence of the species, as plants, rests on recruits from mediocre germination and establishment situations; this has been observed in enclosures of Mitchell grass (*Astrebla* spp.), species which appears to respond best to substantial spring or early summer rainfall – an infrequent event. In addition to these well-timed rains and follow-up rains over summer, the Mitchell grasses appear to establish best where a large proportion of the soil surface is bare.

The response of a species population to normal levels of grazing and cessation of grazing is known to differ between species; this is probably true for other management treatments and should be determined. In addition, studies suggest that the demographic performance of a particular species can change along acline (north-south) from favoured by cessation of grazing to unaffected by grazing; a comparison species exhibited the reverse performance.

These and other observations have yet to be incorporated into practical measures for combating desertification. However, it can be appreciated that rigid deferment systems and long-term deferments may be unnecessary, making way for opportunistic deferments; these could be seasonal deferments and deferments of several years depending on the strength of the observed recruitment; seasonal heavy use on a once-only basis for undesirable perennial weed species that have just recruited, or the use of fire treatments are possibilities. Certainly there is a greater possibility of success in the well-tried techniques of plant introduction, pitting and furrowing, water ponding, grazing deferment and burning if the performance of the plant populations to be advantaged or disadvantaged under these treatments is understood in the way that the performance of the rabbit is understood.

BANGLADESH

Action Taken or Proposed on the Plan of Action to Combat Desertification

The riverine deltaic country of Bangladesh is primarily dependent on its water resources fed by the three major river systems viz. Brahmaputra-Jamuna, Ganges and Meghna originating outside her national boundaries.

An unspecified but huge quantity of low water supplies of the Ganges was diverted unilaterally by the upper riparian during 1976, starting a chain of immediate adverse effects on different economic sectors of Bangladesh. The most important of these are the effects on the agricultural sector. The salinity from the Bay of Bengal intruded into the river and land masses in the south-western region of the country thus affecting the prevalent system of agriculture, forestry, fishery, ecology etc. of the region. Thus, together with depletion of the moisture in the soil, set in what may be called a desertification process in the south-west region of Bangladesh.

After peristent efforts by the Bangladesh Government and through the good offices of the U.N. General Assembly, India and Bangladesh reached a short-term agreement for 5 years from 1978 to share the dry season flows of the Ganges on an agreed schedule from 1st of January to 31st May each year. This agreement has to some extent helped Bangladesh minimise the degree of the adverse effects that occured in 1976, but although at a comparatively lesser degree, these are still continuing in the country without attainment of the normal conditions of the prediversion period (before 1976). It is evident that such continuous adverse effects will result in some permanent losses in the near future.

Despite the enormity of the problem, in order to meet the situation the Government of Bangladesh has accorded highest priority to agriculture and rural development, allocating a large percentage of its overall budget for this task. The principal aim is to boost food production and improve crop yields through low-cost, labour-intensive projects and by expanding the use of the new high-yielding rice varieties. Intensive planning has been underway on an integrated and multi-disciplinary approach backed by institutional development. Besides the national authority, local agencies at village and district levels are being utilised for undertaking agriculture and rural development and water conservancy projects. Special emphasis has been placed on motivating the people for self-reliance through the rural works and Food for Work Programmes. Intensive irrigation facilities have been conceived, particularly during the dry months, to enable the farmers to grow 2nd and 3rd crops to meet the people's need. In developing the water resources, care has also been taken to provide facilities for river training, land reclamation and protection of coastal areas from saline inundation from the sea.

The development of the south-western region through some immediate steps, short term projects and then through a long-term scheme is being planned. However, the long-term scheme will depend on the success of the outcome of the deliberation being continued by the Indo-Bangladesh Joint Rivers Commission of low water supplies of the Ganges.

In spite of our best endeavours Bangladesh faces a serious constraint beyond our control. Since 80 per cent of the river flows are generated from outside, one cannot arrest the desertification process, let alone reverse it, without international and regional co-operation.

The need for harmonizing national action taking into account the effects on co-basin states, for adopting universally applicable rules of co-operation in the allocation, utilisation and conservation of the water resources and, to this end, for the evolution of appropriate mechanism for exchange of information and for consultation and peaceful settlement of disputes and misunderstandings, has today become an imperative fact of our inter-dependency.

The duty of the states must be to co-operate on the question of shared resources on the basis of sovereignty, equality and the territorial integrity of all states and their responsibility under International Law to ensure that activities within their jurisdiction or control do not cause damage to other states or areas beyond the limits of national jurisdiction. The main thrust of those proposals is towards strengthening existing International and National Water Laws as a means of putting co-operation among states on a firmer basis, particularly through the codification and development of the rules of International Law. Even in the absence of bilateral or multilateral agreements it is possible for the states to co-operate with each other for harmonious exploitation of the shared resources and to take measures to prevent desertification process.

The efforts that are being made or proposed by Bangladesh concerning the implementation of the Plan of Action to Combat Desertification are given as follows:

Recommendation 1

This has been in progress since 1976 with the lease data prior to that. Assessment and evaluation of the desertification process for 1976, 1977, 1978, 1979 have been made, whereas evaluation for 1980 is in progress.

The adverse consequences due to a huge man-made withdrawal of the flows from the Ganges on Bangladesh is annexed (Annex 1).

Recommendation 2

Research and study on the basis of accumulated data and survey results will lead to a revision of land-use planning and management. In this connection the Water Development Board has taken up studies for updating the Master Plan, specially of the south-west region. Hydrological and ground water survey are being taken up by UNDP with water balance studies in the region.

Recommendation 3

Resuscitation of dead and dying rivers for water conservation and excavation of new canals for taking the water to the areas of shortage are the works now being accomplished through mass public participation as one of the primary revolutionary steps being taken in the country. However, public participation through FFW programme was introduced much earlier in certain specific projects in Bangladesh. Necessary institutional support is being set up, such as 'Gram Sarkar' (administration at the individual village level). The achievement is given in Annex 2.

Recommendation 4

A number of seminars were held and various publications produced by the Environment Pollution Control (EPC) Department to create public awareness and to highlight the significance of protecting the environmental quality of Bangladesh with a view to preserving the natural eco-system. Another primary purpose of these moves was to motivate the public in the afforestation programme to combat desertification process. Publications in the form of booklets, seminar papers on the generation of bio-gas plant, as well as yearbooks were brought out by the EPC department. In addition, environmental education has been incorporated in the academic curricula for children in schools, and mass media such as radio and television are at work to foster public awareness not to pollute the environment nor disturb the natural eco-system.

As a result of such dissipation of environmental information and educations, the public has been showing keen interest in having a better living environment. Moreover, they have become more aware about the need to utilize renewable resources to meet their demand for energy and the need for afforestation in the country. Bangladesh being one of the 10 members of South-Asia Co-operative Programme (SACEP), laid due emphasis in the last meeting of SACEP in Sri Lanka on the preservation of the natural eco-system in the South-Eastern Region. In the meeting Bangladesh was unanimously selected as the national focal point for mangroves and coral island eco-systems.

Monitoring data on water quality for surface, lake and ground water are being collected year-round from about 20 monitoring stations covering high- and low-flow periods. Included in them are 9 CEMS stations to monitor surface, lake and ground water. The data so collected are being sent regularly to World Health Organisation (WHO) regional office. The data from all monitoring stations have been stored in a data bank since 1973 and are being published in the form of yearbooks from time to time. Industrial surveys have been made in different cities with a view to assessing the adverse effects, where applicable, of industrialization and urbanization from the environmental point of view. These data are also being stored in a data bank and published in yearbooks.

Recommendation 5

This is dependent on the outcome of research and study taken up on the data collected in the affected areas. Environmentally suitable planning for the south-west region of Bangladesh for optimum utilization of the shared water from the Ganges is in progress. This is given in Annex 3.

Recommendation 6

Bangladesh has a shortage of rangelands. However, the lands are mostly cultivated for crop production and the fodder which comes out of these crop fields is consumed by the livestock. The canal digging programme through public participation is an answer to the solution of such degraded farmlands. The system of diversification and integration will also be achieved in due course, once the water is found for the area.

Recommendation 7

Programme for conservation of water as far as possible within the country is under way as mentioned earlier. Conservation and improvement of soil and the rational use of soil moisture have also long been practiced with added emphasis on antidesertification.

Recommendation 8

The irrigation and drainage projects as conceived, planned and implemented in Bangladesh have these criteria inherent within the project to avoid as far as possible any adverse effects. However, the planning may sometimes include some effects to maximise the benefits in the long run thus off-setting the temporary ill effects.

Recommendation 9

The managed forest area of Bangladesh is 3.25 million acres which represents about 9.5 per cent of the total area of Bangladesh. These forest areas are located in the far flung border areas of the country. The vast plain land where the majority of the population lives has very scanty and scattered forest areas under the management of the Forest Department. In Chittagong Hill Tracts distrct in the south-eastern part of the Bangladesh there is 2.4 million acres of Unclassed State Forests (U.S.F.) which are subject to shifting cultivation from time immomorial by the local tribes. The entire U.S.F. land has been rendered treeless and fertility of the soil has declined to such a level that such a vast area cannot sustain even a very small population of tribal people in the district. It has been estimated in a land capability survey that out of the total U.S.F., 1.8 million acres are suitable only for forestry and long-term horticulture.

In the 68,000 villages of Bangladesh there are small wood lots in the homestead areas. The area of such wood lots has been estimated to be 0.6 million acres.

Considering the above facts and limitations, the Forest Department has raised about 400,000 acres of valuable plantations up to 1980 by replacing the low yielding forest areas and in the new accretions along the coastal belts. During the second Five-Year Plan, staring from 1980-81, the Forest Department has taken up the followig programme for improving the vegetation in the northern and north-eastern districts of Bangladesh which are subject to micro-level desertification:

1. Establishment of 113 Forest Extension Centres in the districts of Rajshahi, Rangpur, Dinajpur, Pabna, Bogra, Kushtia and Jessore for the distribution of seed and seedlings and training of rural people in the technique of use of marginal land and stablisation of canal banks. About 70 million seedlings will be distributed to the people from those centres during the period.

2. Supervised afforestation with multiple use species in about 4,000 villages in the districts mentioned above during the 5 years will serve as demonstration villages.

3. Community forestry over 6,000 acres of Government land in Dinajpur, Rajshahi and Rangpur districts during the 5-year plan.

4. Strip plantation along the slopes of the roads, railway line, embankments, canal banks over 2,500 miles in the above 7 districts. In a preliminary estimate, it has been assessed by the Asian Development Bank Mission in February, 1981 that the project will cost about 290 million Taka with a foreign exchange component of 40 per cent to be implemented over the 5-year period tentatively beginning in 1982.

In other districts, the Forest Department has many other development programmes to improve the vegetation covering the managed forest, village homesteads and the U.S.F.

Recommendation 10

For environment and ecological conservation, efforts are continuing to protect the flora and fauna of the country through afforestation programme as mentioned above.

The Forest Department has also taken steps to preserve the original flora and fauna in certain special preservation plots and some sanctuaries. Further, Government has promulgated Wildlife Preservation Act which is applicable throughout the country both inside and outside the forest areas. Steps are being taken to implement the Act.

Recommendation 11

The intraregional co-operation can best be achieved through a programme to be initiated by UNEP through ESCAP.

Recommendation 12

Identification of such factors is a time consuming affair. However, Bangladesh, being fully aware of the consequences, is trying to identify and analyse the factors gradually within the country. But international help and co-operation is a must if Bangladesh is to achieve the best results.

Recommendation 13

The important social and economic factors in Bangladesh are the growth of population, shortage of farmlands and thus increase in the growth of landless people. This causes the migration of people from rural areas to the urban areas to get jobs for their maintainance. With the development of rural areas through the I.R.D.P. (Integrated Rural Development Planning) and intensive family planning projects, Bangladesh is trying hard to reduce the problem. But this will take time and persistent efforts.

Recommendation 14

Thana health complex with family planning programme is being intensified in the rural and urban areas in Bangladesh.

Recommendation 15

This recommendation will be considered in due course when such a contingency arises.

Recommendation 16

The relief and rehabilitation programme of the country takes care of such problems. However the shortcomings, if any, will be eliminated.

Recommendation 17.

Bangladesh is the pioneer in advocating a food insurance scheme on regional basis to overcome such catastrophic losses due to droughts, flood havocs, cyclones and such other natural disasters. Since Bangladesh is a country of food-shortage, the food insurance cushion cannot be created by itself without international co-operation and assistance. The programmes on management, planning and monitoring of data have been mentioned elsewhere.

Recommendation 18

Bangladesh is readily co-operating with all countries of the world to exchange and improve their science and technology with special emphasis on planning and management and utilisation of resources.

Bangladesh Space Research and Remote Sensing Organisation (SPARRSO), formerly Bangladesh Landsat (ERTS) programme and Space Atmospheric Research Centre, has been conducting research since 1968 in the field of meteorology, oceanography, environmental monitoring and other allied fields. SPARRSO has been operating a Satellite Ground Station since 1968 to receive Meteoro logical Satellite data for research and planning. This organization also started receiving satellite imageries from Resources Survey Satellites (LANDSAT) in 1974 and will be receiving imageries from more advance satellites from USA and France. These metsat and landsat data are being used for research in environmental monitoring including the desertification process. Very soon the organization will use its own computer facilities for satellite data processing. In research to combat desertification process, the organization is also using data from Meteorology Department Survey of Bangladesh, Forest Department, Geological Survey of Bangladesh and Bangladesh Water Development Board.

Recommendation 19

Bangladesh is vigourously pursuing the policy for protection of forest resources and to increase the forest areas. The programme is given in *Recommendation 9.* Though at present the rural people are more accustomed to use wood for their energy resources, use of biogas, extension of natural gas system and solar energy are being gradually developed for the rural areas whereas natural gas and electricity are mainly consumed in the urban areas.

Recommendation 20

National programmes have the priority in disseminating knowledge for better and efficient use of water and other anti-desertification means amongst the public.

Recommendation 21

A co-ordinating national council has been established. However, for effective operation a working committee under the national council is being established soon.

Recommendation 22

This is the present practice.

Recommendation 23

Bangladesh is very much inclined to have both financial and technical support from U.N. bodies as proposed in the action plan to achieve the most judicious way for optimum utilization of the water resources in the region to combat desertification.

Recommendation 24

At the national level 21 major meteorological stations are being opened to monitor the data in support of the HMO Programme.

Recommendation 25

National action is not called for.

Recommendation 26

Bangladesh is pursuing the policy of a sound and judicious management of shared water resources through regional co-operation of the countries involved. Accordingly, Bangladesh has proposed the participation of Nepal with Bangladesh and India to develop the water resources of the Ganges judiciously amongst the three co-basin countries.

At present a short term agreement to share the dry season flows of the Ganges (from 1st January to 31 st May) exists with India with effect from 1978 for 5 years.

Bangladesh also reaffirms the recommendation of the U.N. Water Conference in this connection and urges that in the absence of bilateral or multilateral agreements, Member States should continue to apply generally accepted principles of international law in the use, development and management of shared water resources.

Moreover, the work of the International Law Commission in its contribution to the progressive development of international law and its codification of the law of the non-navigational uses of international water courses should be given higher priority in the work programme of the Commission, and should be co-ordinated with activities of the international law of waters with a view to the early conclusion of an international convention.

Recommendation 27

Bangladesh will actively participate in the agreed programmes to combat desertification with UNEP and ESCAP.

ANNEX 1

The adverse consequence of the Indian withdrawal of the Ganges waters at Farakka on Bangladesh economy had been immediate, wide-spread and unprecedented. Some of these are quantifiable. There are some other immediate effects that can only be discussed qualitatively. Two major factors have come up in a degree not foreseen before; first, the magnitude of the negative effects of salinity resulting from decreased down-stream flows and, second, the potential magnitude of the benefits of dry season irrigation. The hazards of salinity experienced by Bangladesh from one year's yet undisclosed heavy withdrawals of the Ganges flow at Farakka have been such as to call for immediate restoration of its dry season flow. The Ganges waters directly affect 21,000 sq. miles or 38 per cent of Bangladesh. 33 per cent of Bangladesh's population lives in the river basin. In addition to agricultural production, the Ganges basin in Bangladesh contains approximately 25 per cent of the nation's industrial capacity.

In the dry season of 1976, the level and discharge of the Ganges waters at Hardinge Bridge fell below the minimum ever recorded. The minimum discharge of the Ganges reached a record low of 23,000 cu. ft. per sec. compared to a historical average of 65,000 cu. ft. per sec. The water level of the Ganges at the Hardinge Bridge registered at 16.5 feet compared to the 22 feet of the normal years. The ground water level fell by 5 feet. The offtake of the river Gorai, the main distributory of the Ganges, went high and dry on March 20, 1976. Reduced flow caused huge shoal formations in the river bed. Irrigation pumps were rendered inoperative. 400,000 acres of agricultural land have been adversely affected resulting in drastic reduction of cropped acreage, and rice production fell by 236,000 tons, approximately 20 per cent of Bangladesh's food import. Winter crops, such as pulses, oil seeds and vegetables could not be planted due to reduced soil moisture. 33 per cent of the irrigation facilities could not operate in the affected region. Fish production fell by 96 per cent at Khulna in April, 1976. Salinity showed marked increase from a normal year average of 500 to 1 000 micromhes per centimeter to 13,600 micromhes per centimeter in April, 1976. Salinity penetrated about 82 miles further inland from the normal incursion limit of 8 miles upstream of Khulna Town.

Inland navigation, the key to Bangladesh's communications system, was disrupted. Both mechanised and country river crafts handle the bulk of the cargo and 90 miles on the main stream of the Ganges were rendered unnavigable. Similarly 45 miles on the Gorai had to be closed for navigation. Many reaches of the distributory rivers were no longer navigable by waterways. Two major ferry terminals had to be shifted, unsettling the established trade and marketing centres.

The operation of the Khulna 60 MW Thermal Power Station which supplies electricity to the major portion of south-western Bangladesh had to be closed down due to high salinity in the waters of the Bhairab river. The corrosive effects of the unprecedented salinity could not be tolerated by the plant, necessitating the carrying of fresh water by barges over long distances. The power station at Bheramara was also rendered inoperative. This interruption in power supply inhibited the industrial production including the production of jute goods, paper and newsprint etc. The Ganges-Kobadak Irrigation Project, the largest in Bangladesh, was affected due to drastic lowering of the water level. The main pumps ran at a lower efficiency and the subsidiary pumps ceased to operate. The situation regarding domestic uses of the Ganges water for purposes including drinking also presented a hitherto unprecedented scarcity of sweet water. The medium and long-term implications of such an unbalancing of nature were incalculable.

There were also some gradual but definite deleterious effects. Increased salinity was estimated to desrease the forest yield in the affected area annually but about 37 cubic feet per acre or 740 cubic feet over the 20-year growing cycle. With the environmental conditions turning increasingly adverse, there are distinct possibilities of millions of people, animals and wildlife gradually migrating to sweet water areas in the course of time when the cumulative effects on the region's ecology will pose unavoidable hazards of living.

Process of desertification has also been evinced in the following areas:

a) Barind Tract, Rajshahi district – 4,955 sq. miles

b) Nadhupur Tract, Mymansinch district – 4,885 sq. miles

ANNEX 2

Achievement in the Voluntary Special Canal Digging Programme and the 'Food for Works' Programme

Most of the flood control, drainage and irrigation projects executed so far, or in progress, adopted labour-intensive items of works viz. construction of flood embankment, excavation of irrigation canals, drainage channel etc. by manual labour. Some schemes are initiated by the local agencies namely Union and Thana Parisads and recommended by the people's representatives. Out of 322 schemes during the current year 122 schemes have been initiated locally.

During 1979-80 a special impetus was attached throughout the country so that irrigation can be given as a measure to increase the food production to achieve the goal of self-sufficiency by1984-85. 250 schemes were taken up for execution during 1979-80 under a special canal digging programme in Bangladesh through voluntary participation of the people. Out of 250 schemes, works on 242 were started. During the period from 1st December, 1979 to 30th June, 1980 works on 183 schemes were completed. A total of 683.6 million cu.ft. of earth works and 651.70 miles of canals were excacavated. Total benefited area of the completed schemes is 0.58 million acres.

Bangladesh Water Development Board has already completed 493 schemes under 'Food for Work Programme', involving construction of 7,740 miles of embankment and the repair and excavation of dead channels. An area of 3.063 milion acreas (1.24 million ha) have been benefited by it up to June 1979. A total quantity of 293,361 tons of wheat has been utilized up to June, 1979.

During 1979-80, a total quantity of 104,000 tons of wheat were allocated. The programme envisaged construction and remodelling of 391 miles of embankment and excavations and re-excavation of 1,055 miles of canals and channels to benefit nearly 1.327 million acres (0.535 million ha.). Works of 120 schemes were completed up to the end of May, 1980, benefiting about 356,517 acres.

ANNEX 3

Planning of the South-West Region in Bangladesh for Optimum Utilization of the Shared Water Resources From the Ganges

The urgent need for new comprehensive planning for the South-west Region was signalled by the recent completion and operation of the Farakka Barrage on the Ganges River, some 10 miles upstream of the Bangladesh-India international boundary. The disastrous effects in the South-west Region of Bangladesh due to the large low-flow diversions at Farakka are well understood. The remedial measures defining realistic short-range and long-range water resources development programmes for the affected areas and proposed future investigations were studied. The Treaty between the Governments of Bangladesh and India on the sharing of the Ganges waters at Farakka and on augmenting its flows, dated 5th November, 1977, gave added impetus to the planning study. The schedule for the diversion of flows (withdrawals by India and releases to Bangladesh), as annexed to the Treaty, is based upon 75 per cent availability calculated from recorded historic flows. Under this schedule, the release during the minimum 10-day flow period, April 21-30, is 34,500 cubic feet per second (cusecs). The Treaty provides for carrying out investigations and schemes related to the augmentation of the Ganges dry-season flows with a view to finding solutions. Progress has been made in this direction, most notably in a meeting of the Joint Rivers Commission (JRC) in early May 1979 during which the two governments agreed to approach the Government of Nepal for the purpose of discussing possible construction of storage dams in Nepal.

BASIS FOR PLANNING

For immediate and short-range development of the Ganges River flows released at Farakka will be as defined in the Treaty. Long-range development will be based upon the augmentation of Ganges flows as proposed in the Treaty. It is not realistic to assume that all flows at Hardinge Bridge, whether according to the Treaty provisions or after augmentation, will be available for utilization in the Study Area for irrigation, water quality control, fisheries and navigation. An allocation of Ganges flows will be required for navigation and control of saline water intrusion.

A nationwide plan for ultimate development is needed to resolve conflicting and competing interregional demands for water. The South-west Regional Plan will provide results based on a planning that will be compatible with integrated nationwide planning.

LOCATION AND DEFINITION OF STUDY AREA

The Study Area to which the planning applies consists of the South-west Region of Bangladesh (all of the lands south and west of the Ganges-Padma-Lower Neghna Rivers) plus adjacent areas north of the Ganges in Rajshahi and Pabna districts for which the source of irrigation water supply is the Ganges River. This area is shown on Fig. I.

DESCRIPTION OF THE PLAN

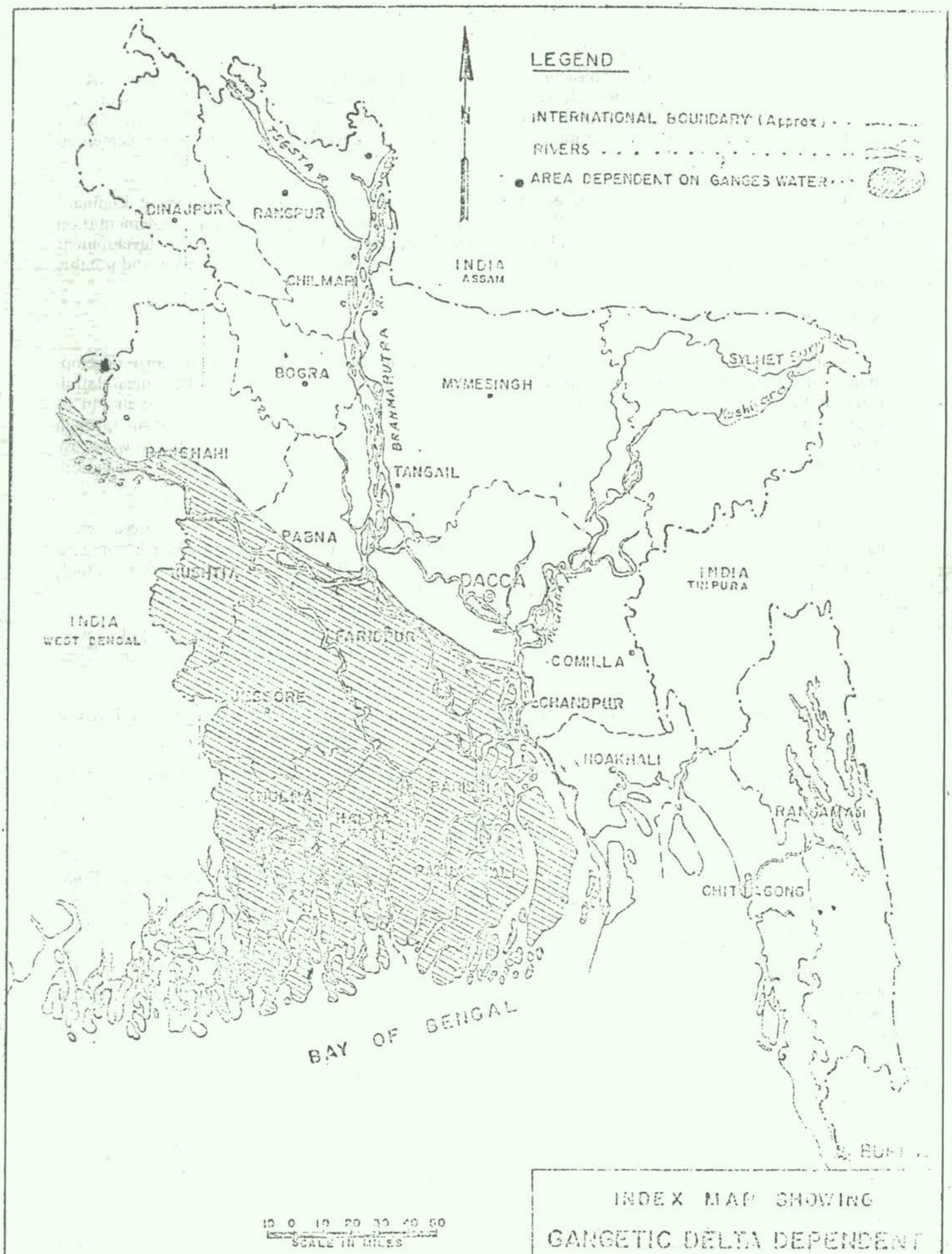
The Ganges River is the principal source of water for the Study Area. The Gorai River, the main distributory of the Ganges in Bangladesh, is the main supply artery for the central part of the South-west Region and for which, one function is to control saline water intrusion at Khulna. The Arial Khan, the other significant Ganges distributary, is considered to be the main supply artery for the eastern part of the region (most of the area east of the Gorai/Madhumati), at least for the immediate future. The availability of flow for diversion into those distributaries must take into account full utilization of the existing Bheramara pumping station of the Ganges-Kobadak Project, and also the irrigation demands of the Barisal Irrigation·Project, now under construction. The latter project is in the nonsaline tidal zone with water supply derived largely from the lower Meghna.

The Gorai and Arial Khan are deteriorating rivers depending on the offtake conditions. Till 1974, Gorai flows were generally sufficient for controlling water salinity at Khulna, but continuous dredging during the low-flow season was required to maintain this minimum flow. Dry season flow in the Arial Khan is virtually zero in low-flow years. Extensive and increased dredging in the vicinity of the offtakes of both rivers will be required as an immediate and continuing programme, if the channels are to provide sufficient water for the expansion of irrigation and salinity control. The need and justification for regulators across the offtake will be carefully studied.

Maximum utilization will be made of the Old River and numerous other natural channels for the supply and distribution of irrigation water. Deepening, cleaning and improvement of these channels will be an important aspect of development. The improved channels will also reduce the depths and duration of flooding through improved drainage. It is anticipated that low-lift pumping from the channels will generally be necessary for irrigation. However, a large part of the Study Area is comprised of natural polders from which ground level generally slopes away from the top of the natural levees forming the river banks of existing and former channels. The use of water level structures along the channels to permit gravity irrigation is being studied.

The need and justification for the Ganges Barrage to assure maximum utilization of the minimum allocated Ganges dry-season flow in Bangladesh are evaluated relative to both short-range and long-range requirements. In addition, the feasibility of pumping plants on the Ganges River are to be considered and evaluated.

All potential sources of water are incorporated in the regional planning study. Groundwater development, particularly areas in the north-west part of the South-west Region and in the Rajshahi



INDEX MAP SHOWING
GANGETIC DELTA DEPENDENT
ON GANGES WATER
IN BANGLADESH.

area north of the Ganges will be considered. Local surface water may be a significant factor particularly in the lower areas. The possible closure of some estuaries and use of a channel network upstream for storage of local flows will be analysed. Following construction of a diversion structure or pumping plant(s) on the Ganges, groundwater and local flow development would be supplemented by flows diverted from the Ganges.

The conceptual planning described above deals primarily with irrigation, which is the dominant requirement for water development in the region. However, successful planning and implementation depend upon a balanced development plan in which all aspects of life, environment and development are appropriately planned and accounted for such as fishery, navigation, ecology, forestry and potable water supply.

STAGE OF DEVELOPMENT

Planning studies are performed for (i) **immediate development** and (ii) **short-range development** and for (iii) **long-range development**; for the present, planning is based upon the general definitions of these three stages of development as given below. In reviewing the definitions it should be kept in mind that the primary development objective is increased agricultural production through irrigation, drainage and flood control. It is implied that all other planning aspects related to water use and availability, such as, water quality control, development of the fishery industry, navigation, environmental and other factors are inherent in planning at all stages.

1. **Immediate Development**: The primary objective characterizing the immediate development stage is to achieve the most rapid possible increases in agricultural production which is compatible with the national goal for increasing agricultural production. With this primary objective in mind, certain likely characteristics of projects selected for this stage can be envisaged:

- The service areas will be readily accessible to natural channels that can be supplied with Ganges river water carried into the Study Area by the Gorai/Madhumati and Arial Khan Rivers.

- Dredging and possibly control structure(s) at the offtake(s) to increase the low flows of these distributaries, and improvements of other channels will be required.

- Development will require a minimum of engineered works, foreign exchange and total investment, and will involve a short gestation period.

- Areas will not be subject to deep flooding.

- Emphasis will be on irrigation, thus areas selected for Immediate Development will not necessarily become complete projects. For example, if peripheral dikes (polders) are indicated this aspect may be deferred for later inclusion in the Short-Range Development Stage or later.

Projects which have been completed, projects presently under construction and projects for which funding has already been arranged will be studied in sufficient detail so that their operations can be incorporated into the regional plan. As shown in Fig. 2, the most important projects in these categories are:

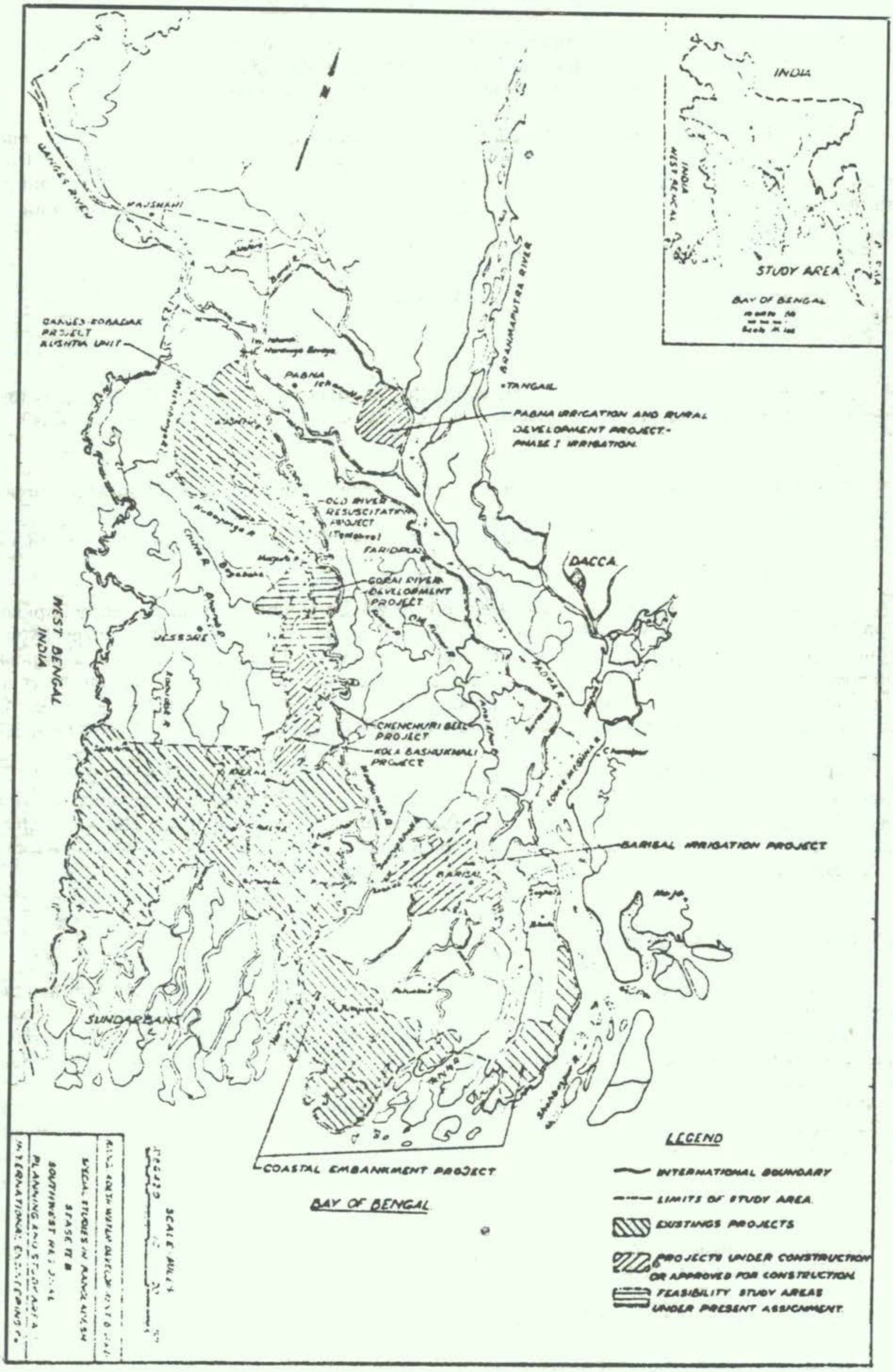
- The Kushtia Unit of the Ganges Kobadak Project (largely completed).

- The Barisal Irrigation Project (under construction).

- The Chenchuri Beel and the Barnal-Salimpur-Kolabashukhali polder projects.

- Pabna Irrigation and Rural Development Project Phase I.

- Coastal Embankment Project – Project planning will consider the delivery of fresh water



INDIA
STUDY AREA
BAY OF BENGAL
GANGES RIVER
RAJSHAHI
GANGES-KOBADAK PROJECT KUSHTIA UNIT
PABNA
TANGAIL
BRAHMAPUTRA RIVER
PABNA IRRIGATION AND RURAL DEVELOPMENT PROJECT-PHASE I IRRIGATION
OLD RIVER RESUSCITATION PROJECT
FARIDPUR
DACCA
GORAI RIVER DEVELOPMENT PROJECT
JESSORE
WEST BENGAL INDIA
CHENCHURI BEEL PROJECT
KOLA BASHUKHALI PROJECT
BARISAL IRRIGATION PROJECT
BARISAL
SUNDARBANS
COASTAL EMBANKMENT PROJECT
BAY OF BENGAL
LEGEND
INTERNATIONAL BOUNDARY
LIMITS OF STUDY AREA
EXISTINGS PROJECTS
PROJECTS UNDER CONSTRUCTION OR APPROVED FOR CONSTRUCTION
FEASIBILITY STUDY AREAS UNDER PRESENT ASSIGNMENT

to the polders for irrigation. Construction and operation of the polder system may have been instrumental in the accelerated siltation of the tidal channels and cross channels. This condition and possible means of alleviation will be studied.

2. **Short-Range Development**: As a conceptual base, the combination of projects comprising the short-range stage are taken to comprise the ultimate development of the Region with water supply availability fixed by the existing Treaty provisions. The comprehensive plan will take into consideration all aspects of development, all resources and all water related requirements including:

- Complete utilization of Ganges River flows available for irrigation.
- Flood control embankments, mostly polders and drainage.
- Groundwater development.
- Full utilization of local runoff primarily for irrigation. The cutoff of estuaries for the formation of holding reservoirs will be analysed with a careful overview of possible impact on the environment.
- Development of the fishery industry, based upon both fresh and brackish water supply.
- Navigation, potable water supplies, environmental requirements, salinity control and the forests.

Some projects of the Short-Range Development will be suitable for relatively early implementation, others will remain more conceptual in nature and viewed under a longer term perspective. The detail of planning and of the economic and financial appraisal will be variable in the same manner. Some projects will be studied and evaluated in detail similar to Immediate Development Projects and others will be studied in much less detail, similar to Long-Range Development planning. A list of irrigation projects under immediate and short-range stages with their areas are given in Enclosure I.

3. **Long-Range Development**: The central characteristic of this development stage is that water supply will be based upon augmentation of the Ganges River flows, and the objective of planning will be ultimate development of land and water resources. The detail of planning and evaluation will be sufficient to establish manageable development units with a logical sequence and time frame of implementation, and to establish physical and economic viability.

GENERAL SEQUENCE OF PLANNING

The actual sequence of the planning effort will differ from the sequence implied in the descriptions of proposed development stages. A brief description of general work sequence as presently envisaged is pertinent to further define the development stages. These descriptions deal primarily with water resource development with the primary purpose of increasing agricultural production. Because the resources of the South-west Region are predominantly agricultural, development and its planning are deeply involved in, and affected by, all other aspects and resources of the Region, for example, human, economic, business, educational requirements, political and social structures. All these disciplines will participate in an integrated manner, and inputs and interplays are implied in all descriptions.

1. **Immediate State Projects**: The identification, planning and preliminary ranking of these projects will have highest priority. Regional planning maps with preliminary project delineations and river profiles will be the basic tools for all stages of development planning.

2. **Selection of Priority Immediate Projects**: The nature and objectives of the two feasibility studies included in the study programme are given below. The demarcation of areas for the two projects was an early requirement of planning.

- The Gorai River Development Project area was selected early in the study so that field investigations could be initiated immediately to maximize work accomplishment prior to the start of the monsoon rains. The principal requirement of the Gorai Project concerns the improvement of the Gorai River itself, a necessity for the development of other nearby projects in the Region.

- The Old River Resuscitation Project area was tentatively selected to permit a general field inspection of the area prior to the monsoon season.

During the course of planning, the Study will also identify the second phase of priority projects for which feasibility studies will be recommended. These could include the following:

- Additional irrigation projects utilizing Gorai River flows, if there is sufficient water.

- An improvement project for Arial Khan and initial irrigation development based on the resulting increased flows.

3. **Long-Range Stage Projects**: In order that the features of the Short-Range Stage Projects be compatible with those of the Long-Range Development, it will be most efficient to plan the latter initially and then select the Short-Range State Projects from this ultimate plan.

4. **Short-Range Stage Projects**: In general these projects will be established by reducing the irrigation features of the Long-Range Development plan until the water requirements are within the water supply availability defined by the Ganges River Treaty.

5. **Additional steps for drinking water supply**: 500 deep set pumps have been installed for drinking water in Rajshahi and Kushtia districts. A programme has been undertaken to set up a total of 400,000 drinking water tube wells in Bangladesh with the support of UNICEF and resinking of 60,000 tube wells. Out of these pumps, 67,000 have been installed in the South-west Region. The first phase of the programme costing Tk. 260 million is completed and the second phase costing Tk. 560 million is in hand.

Enclosure 1

IRRIGATION PROJECTS

GANGES RIVER SERVICE AREA

IMMEDIATE AND SHORT-RANGE DEVELOPMENT STAGE

IRRIGATION COMPLEX/PROJECT	GROSS SERVICE AREA-ACRES			MET SERVICE AREA-ACRES
	Immediate stage	Additional Short-Range	Total Short-Range	Total Short-Range
1	2	3	4	5
I DIPECT GANGES DIVERSIONS				
A.GORAI/MADHUMATI				
West Bank Complex				
Kushtia Unit-Phase I	103,000	–	103,000	74,200
Intergrated Land & Water use	79,000	–	79,000	59,300
Gorai	127,000	–	127,000	85,400
Old River	66,270	23,450	89,720	67,300
Chenchuri Beel	66,400	–	66,400	52,000
Sub-Total	441,670	23,450	465,120	338,200
East Bank Complex				
Kamarkhali	39,810	–	39,810	29,900
Chitra	27,120	–	27,120	20,300
Baliakandi	55,140	–	55,140	41,400
Barasia	71,870	–	71,870	53,900
Sub-Total	193,940	–	193,940	145,500
SUB-TOTAL – Gorai	635,610	23,450	659,060	483,700
B G-K. PROJECT-KUSHTIA UNIT				
Bheramara Off-take	359,000	–	359,000	257,000
C. MATHABANGA – BASED				
Mathabanga Complex				
Daulatpur	30,770	–	30,770	23,100
Bagmari	42,170	–	42,170	31,600
Damurhuda	50,210	29,310	79,520	59,600
Kajla East	–	53,660	53,660	40,500
Sub-Total	123,150	82,970	206,120	154,500
Chitra/Nabaganga Complex				
Chitra II	–	60,540	60,540	45,400
Chitra III	71,040	–	71,040	53,300
Chitra IV	50,480	–	50,480	37,900
Sub-Total	121,520	60,540	182,060	136,600

Enclosure 1 *(Continued)*

IRRIGATION COMPLEX/PROJECT	GROSS SERVICE AREA-ACRES			MET SERVICE AREA-ACRES
	Immediate stage	Additional Short-Range	Total Short-Range	Total Short-Range
1	2	3	4	5
Kobadak Complex				
Jibannagar	–	89,540	89,540	67,200
Mahespur	–	54,080	54,080	40,600
Chougacha	35,560	–	35,560	26,700
Jhingergacha	73,030	–	73,030	54,800
Kisabour East	–	5,980	5,980	4,500
Harihar West	–	61,660	61,660	46,200
Upper Kalaroa	–	44,960	44,960	33,700
Sub-Total	108,590	256,200	364,810	273,700
Lower Bhairab Complex				
Lower Bhairab	–	36,630	36,630	27,500
Afraghat	39,810	52,360	92,170	69,100
Sub-Total	39,810	88,990	128,800	96,600
SUB-TOTAL-MATHABANGA	393,070	488,720	881,790	661,400
D. FARIDPUR/UPPER BARISAL				
North Faridpur Complex				
Kumarkhali North	–	45,670	45,670	34,300
Goalunde – 29,550	–	65,030	65,030	48,800
Sub-Total	–	110,700	110,700	83,100
Chandana/Kumar Complex				
Kumarkhali East	–	29,080	29,080	21,800
Narayanpur	–	59,160	59,160	44.400
Tamarhazi	–	29,580	29,580	22,200
Sub-Total	–	117,820	117,820	88,400
SUR-TOTAL FARIDPUR	–	228,520	228,520	171,500
E. NORTHWEST COMPLEX				
Southern Rajshahi				
Phase II	–	101,600	101,600	74,400
Pabna Phase III	–	88,000	88,000	70,000
Sub-Total	–	189,600	189,600	144,400
TOTAL-DIRECT GANGES	1,387,680	930,290	2,317,970	1,718,000

Enclosure 1 *(Continued)*

IRRIGATION COMPLEX/PROJECT	GROSS SERVICE AREA-ACRES			MET SERVICE AREA-ACRES
	Immediate stage	Additional Short-Range	Total Short-Range	Total Short-Range
1	2	3	4	5
II TEMPORARY DIVERSIONS – OTHER SOURCES (From Immediate Stage)				
A. PABNA AREA	189,870	–	189,870	151,500
B. ARIAL KHAN COMPLEX	372,420	–	372,420	287,300
C. UPPER BARISAL COMPLEX	100,000	–	100,000	70,000
TOTAL-OTHER SOURCES	662,290	–	662,290	508,800
TOTAL-GANGES RIVER AREA	2,049,970	930,290	2,980,260	2,226,800

CHINA*

The Transformation of Deserts in China:
A Summary View of the People's Experiences in Controlling Sand

Arid lands in China include gravelly gobis and sandy lands in the arid and semi-arid steppes. The term *sandy land* distinguishes dune formations in the steppe zones from those in true deserts with their different natural conditions. Occurring mainly in north-west and north China, with a few in the north-east, the arid lands cover an area of 1,095,000 sq.km. or 11.4 per cent of the total area of China. Sandy conditions, including lands, affected by wind erosion, prevail on 59 per cent of the arid lands while gravel desert occupies 41 per cent. They spread over the Inner Mongolia Autonomous Region, the Ningxia Hui Autonomous Region, the Xinjiang Uygur Autonomous Region, and the provinces of Shaanxi, Qinghai, Liaoning, Jilin and Heilongjiang.

Over the years before liberation in 1949, the people living in China's desert areas were oppressed and exploited. As their natural resources were wasted and plundered, they were forced to retreat before the advance of wind-driven sands. Since the founding of the People's Republic of China, they have embarked on the mass movement, "in agriculture, learn from Dazhai". In the spirit of self-reliance and hard struggle that typified Dazhai, the famed agricultural production brigade, a part of the Dazhai People's Commune in the Daihang Mountains of eastern Shaanxi, Chinese farmers mapped out a general programme around the principle that desertification should be dealt with in terms of local conditions. Comprehensive measures were developed in a co-operative spirit, with scientific and technical personnel working closely with the farmers. As a result, a number of achievements were realized, the basis for sand control established, and considerable progress in animal husbandry and agriculture recorded.

The Distribution and Characteristics of China's Arid Regions

The arid regions of China are mostly typical of the temperate zone arid lands and are mainly distributed in inland intermontane basins, with some 90 per cent of them concentrated in the arid zone west of 106° longitude – the heart of the continent. Most of these lands get less than 200 mm of annual rainfall, and with annual evaporation reaching as high as 3,500-4,000 mm, the aridity index is above 4.0, rising even beyond 6.0 in the desert in the Tarim Basin.

On sandy lands, vegetation cover is sparse, with shifting dunes occupying 75 per cent of the area. Fixed and semi-fixed dunes occur only in the Junggar Basin and in certain lake basins as well as along the banks of intermittent streams and on the frontal margins of alluvial fans on the deserts. Irrigated oases are distributed along the river banks on the desert fringe, with major farming centres located on the middle and lower reaches of piedmont alluvial fans.

To the east of 106° arid and semi-arid steppes with sparsely distributed dunes and small gobis constitute only 10 per cent of China's total arid lands. As it approaches the sea, this region is more affected by the south-east monsoon. Here, annual precipitation averages 200-450 mm which, with annual evaporation of 1,500-2,500 mm, yields aridity indexes of 1.5-4.0. Vegetation grows fairly well here. Besides grasses, herbs and shrubs, trees are found growing on the semi-fixed dunes that constitute 80 per cent of the total dune area, with shifting dunes dotted sparsely here and there.

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* This is an extract of the report entitled "Combating Desertification in China" on a seminar sponsored by the Academy of Sciences of the People's Republic of China and the United Nations Environment Programme. It was prepared by the Department of Desert Research, Lanzhou Institute of Glaciology, Cryopedology and Desert Research, Academica Sinica, and was previously published by the United Nations Environment Programme, Nairobi, 1982.

The deserts and arid lands of China are distributed over the vast area lying between 35° and 50° north latitude and 75° and 125° east longitude. Affected by local factors – precipitation and temperature, vegetation and landforms – they show distinct natural characteristics.

The Taklimakan Desert in Xinjiang, with an area of 327,000 square kilometres, is the largest in the country. It is famed for the huge size of its moving dunes, generally 100-150 m in height, as well as for their morphological complexity, with composite dunes constituting two thirds of the dune area. Along rivers extending into the interior of the desert, intermittent floods and ground water sources support *Populus diversifolia* and *Tamarix chinensis*, forming natural green belts in an otherwise empty landscape.

The Gurbantünggüt Desert is characterized by an extensive distribution of fixed and semi-fixed longitudinal sand dunes. These are covered mainly by *Haloxylon ammodendron*. Near the wind-gap to its west, this desert shows a rich display of wind-eroded geomorphic features. The Badin Jaran Desert presents a spectacular landscape of huge bare sandhills averaging 200-300 m in height and constituting 68 per cent of its total area. These are dotted with lakes. The Tengger Desert is characterized by shifting sand dunes interspersed with grasslands bordering on lake basins. The Qaidam Basin, the highest desert in the country, averaging 2,600-3,400 m above sea level, is typified by a patchy distribution of dunes amidst densely grouped wind-erosion lands that constitute 67 per cent of its total area.

Set amidst arid and semi-arid steppes, the Mu Us sandy land is a region of varied landscapes. Arrays of shifting sand dunes occur amidst fixed and semi-fixed dunes, lake basins and valley terraces. The Orzindag, Horquin and Hulun Buir sandy lands in the eastern steppes show a considerable number of lake basins and a predominance of fixed and semi-fixed sand dunes on which *Pinus sylvestric* var. *mongolica, Pinus tabulaeformis,* and other trees flourish amidst grasses and shrubs.

In combating desertification, the people living in the deserts and arid lands have developed a number of effective measures. These take account of the special features of their environments.

In sand deserts, shelter belts of trees and shrubs are planted around oases and farmland as a protection against sand drift, while windbreak networks are planted within the cultivated areas so as to protect the crop plants. Grasses are planted in the fringes of the surrounding desert to stabilize moving sand. Where possible, surface water is used for levelling dunes.

In sandy lands where shifting dunes occur amidst a prevalence of fixed and semi-fixed dunes, *grass kulums* are built and a rational use of pastures pursued to develop animal husbandry. The word *kulum* is a Mongolian term for enclosures of dunes, natural meadows or plots between dunes where water and soil conditions are favourable. The enclosures are constructed of barbed wire, earthen bricks or wicker fences so as to protect the land from grazing and other activities. Pastures are protected against desertification by stabilizing dunes through plantings, by fencing off ranges and by constructing protective forest belts.

In most desert areas, new oases are developed on lake basins, on desert rims and on the banks of rivers extending into the deserts by building reservoirs to store the waters of intermittent floods, by building ditches to collect and divert runoff from snow in the mountains, and by tapping ground-water resources from alluvial-lacustrine deposits. In such oases, the land is levelled, shelter belts planted, soil quality improved and barren lands reclaimed.

Along railways and highways that pass through deserts, engineering measures are adopted to stabilize moving sands. Protective straw palisades are built in a checkerboard within which sand-fixing vegetation is planted. Where this is not sufficient, additional measures to fix, block or remove sand may be taken as circumstances warrant.

Measures for Combating Desertification in China

In accordance with the principle of adaptation to local conditions, effective measures to control desertification depend upon what calls for protection – whether farmland or pasture, roads or railroads.

Forest and shelter belt networks to control blowing and drifting sand.

On the fringes of oases where irrigation is possible and dunes no higher than 10 m with depressions between them, forests for protection against sand are generally arranged in belts and patches. A loose-structured belt of trees 50-60 m wide is established along the main ditch on the fringe of the oasis. It is supported by patches of trees – usually *Populus cupidata* and *Elaeagnus angustifolia* – in the depressions between sand dunes adjacent to the belt, both watered by ground water or what can be spared from the irrigation of crops. Sand dunes are thus surrounded and partitioned off. Within the trees air currents are no longer saturated with sand, and the movement of dunes comes to a halt. Even without further measures, dunes 4-5 m high will decrease 1-2 m in height within three or four years. Trees to control sand movement have been planted on the Hexi Corridor in Dunhuang, Linze, Gaotai and other districts.

On some shifting sand dunes between tree patches, artificial barriers are being erected, composed of locally available materials, such as clay, wheat straw, stalks or gravel, increasing the roughness of the surface and checking wind velocity (see Table 1). Sand-fixing plants will then be established inside the barriers. At Minqin, clay barriers reduced wind velocity 28-33 per cent and stabilized the sand surface, thereby assuring the survival of the seedlings of such sand-fixing plants as *Haloxylon ammodendron*. At Shajingzi, west of the Minqin Desert, such measures turned shifting sands into semi-fixed dunes and improved the density of the vegetation cover on the dunes from an original 3-5 to 30-40 per cent.

Table 1. Effects of clay sand barriers on surface roughness and wind velocity (on the western fringe of the Tengger Desert)

Type	Wind velocity value (%)	Wind velocity reduction inside barriers (%)	Roughness (cm)
Shifting sand surface outside barriers	100		0.0025
Checkerboard-shaped barriers made of clay	72	28	0.4923
Belt-shaped barriers made of clay	67	33	0.4923

For oases on the periphery of deserts with flat soil interspersed with shifting and semi-fixed sand dunes, forests for sand protection are generally composed of trees together with shrubs, such as *Tamarix ramosissima*. The shrubs are placed facing the desert to check wind and sand movement at the surface, while the trees are placed on the farmland side. Data obtained at Pishan, south-west of the Taklimakan, show that with a medium velocity wind, air passing through *Tamarix chinensis* has its sand content reduced by 80 per cent. The nearer they are to the sand sources the denser the shrubs should be.

At Minqin, for example, belts of shrubs are 300-500 m wide to reduce the sand content of the air, to minimize sand accumulation and to facilitate irrigation of the trees which, planted in 50 m wide belts, further check air speed and reduce its sand content. This arrangement has also been established at Yumen in the Hexi Corridor, in the new reclamation region on the lower reaches of the Tarim River and at some of the oases to the south of the Taklimakan. At Shache, Markit and other oases on the western fringe of the Taklimakan, the sand-preventive shelter belts, generally 180-200 m wide, are mainly composed of *Eleagnus angustifolia*, a vigorous tree whose dense branches and leaves are effective in reducing wind velocity at the ground surface and lowering the sand content of the air.

A medium wind will be checked in velocity by 40-57 per cent within the belt, whose protective range extends 23 times its height.

In the north-eastern part of the Ulan Buh Desert, shelter belts bordering the oases are looser and wider, averaging 300-400 m, and the trees on the side facing the desert are combined with shrubs and grasses to fix shifting sand. Within a range of 30 times the height of the trees, the average drop in wind velocity is 50-60 per cent, while 70 per cent of the sand content within 20 cm above the ground is blocked at the front edge of the shelter belt.

For the oases situated near the frontal margins of gravel gobis or wind-erosion lands where strong, sand-laden wind constitutes the main problem, the general practice is to adopt a system of alternating belts and ditches. At the wind gap in the Wuxing People's Commune, Turpan, Xijiang, the Wudaozhu shelter belt displays to full advantage this arrangement of multiple, combined belts and ditches. The ditches are dug – 1.5 m wide and 4.5 m apart – before the trees are planted. This assures easy irrigation, high survival rate of saplings, water economy, and the convenient removal by water of accumulated sand. In choosing plant species, the emphasis is placed on long life, quick growth, and dwarf varieties with large crowns. Along the first windward ditch is a belt of *Eleagnus angustifolia* which has high wind and sand resistance as well as salt-alkali tolerance. At each of the next two ditches one row of *Populus bolleana* and one row of *Ulmus pumila* are planted. Each of the two leeward ditches is planted with one row of *Populus bolleana* and one row of mulberry (*Morus alba*). This arrangement provides a stable structure having at the same time an uneven or zigzag profile at the treetops which cuts wind velocity... Within a distance equal to 1-3 times the shelter heights behind the belts, a medium wind is cut to 26.7 per cent of its unchecked speed, while at a distance of 7 shelter heights wind is still cut to 29 per cent. At Turpan, perimeter belts of this type are combined with shelter belt networks planted within the oasis. This combination has proved effective in protecting farmlands from strong winds and blowing sand.

Different species of trees and shrubs are for planting in different places. In the oases bordering the Xinjiang deserts, suitable tree species include *Populus bolleana, Eleagnus angustifolia* and *Ulmus pumila*. *Tamarix chinensis* is a well-adapted shrub. In the Hexi Corridor, *Populus cupidata* and *Eleagnus angustifolia* are the usual trees and *Haloxylon ammodendron* is the typical shrub. In the Ulan Buh Desert, *Salix matsudana, Populus simonii* and *Eleagnus angustifolia* prevail. Long experience has shown that for fixing sand and stability of plantation a combination of several species is better than one.

Within oases, networks of shelter belts must also be planted simultaneously with the establishment of protective belts at the perimeter, and the two must be integrated into one protective system. Only in this way can full protection be achieved. Experience shows that successive shelter belts, integrated into a multiple network, have the effect of successively lowering wind velocity as shown in Table 2. At Markit, Shache, Pishan and Turpan, tight networks of narrow belts have been established. Observations made at Turpan, where the problem of drifting sand is the most severe, show that small networks are 7.4-26.7 per cent more effective than large networks in cutting wind velocity.

Table 2. Average wind velocity behind shelter belts as compared with open field

	Percentage
Open field	100.0
First belt	38.0
Second belt	42.0
Third belt	51.1

In oases on the rim of the Taklimakan, the distance between main forest belts averages 200-400 m, and between secondary belts, 300-500 m, each composed of four to eight rows of mixed trees of different heights, providing two-layer canopies. Networks of this type show a remarkable ability to break the wind as shown in Table 3. In the farmland shelter belts in the southern part of the Mu Us sandy land in northern Shaanxi, the main belts are usually composed of five to six rows of trees over a width of 8-11 m, while the secondary belts are established in three to four rows averaging 6-8 m wide, both belts occupying a total of 7 per cent of the land. Networks of trees on the edge of an oasis where drifting sands run rampant could be composed of belts with various distances between them depending on the wind velocity. Experiments conducted at Turpan show that a a satisfactory arrangement establishes 15 heights between the first and second belts, 15-17 heights between the second and third belts, and about 30 heights from then on, with shrubbery along the first and second belts to form semi-closed structures.

Table 3. Protective effect of narrow shelter belts against wind (on western fringe of Taklimakan Desert)

Distance in multiples of forest height behind belts	Percentage of drop
Open field	0.00
1 *H*	78.92
3 *H*	61.11
5 *H*	61.11
8 *H*	50.00
10 *H*	46.30
15 *H*	25.50
20 *H*	15.70
25 *H*	15.70

The efficient protective range of shelter is usually expressed in multiples of belt height as their wind-blocking efficiency is proportional to their height. Under conditions in which wind velocity and penetration are similar, observations show that when shelter belts consist of six rows, the average drop in wind velocity 1-30 heights behind the belt is 32.2 per cent if $H = 10$ m and 20.9 per cent if $H = 6$ m. as shown in Table 4.

Table 4. Wind-braking effects of belts of varied heights

Height of belt (m)	Coefficient of wind penetration	Relative value of wind velocity at test points behind belts with that of the wind velocity unchecked as 100							Average drop within 1-3 H behind belt (%)
		1 *H*	3 *H*	7 *H*	10 *H*	15 *H*	20 *H*	30 *H*	
6	0.54	84.4	51.1	57.8	77.8	86.7	95.6	100.0	20.9
10	0.52	67.5	47.5	47.5	60.6	70.0	80.0	95.0	33.2

Farmland shelter belts are preferably composed of fast-growing indigenous plus a small proportion of long-life species. In Turpan Basin, characterized by extreme aridity, high temperatures and strong winds, shelter belts are properly designed in multiple layers with a loose structure. *Ulmus pumila* and *Populus bolleana,* key species for narrow shelter belts, are planted in the centre of the belt so as to ensure the necessary height and sustained protective effect. Rows of *Eleagnus angustifolia* are planted on the belt's windward side so that in their young stage, their curved branches and luxuriant foliage will serve as shrubbery, while in their mature stage, their crowns may extend sideways to shade *Ulmus pumila,* thus permitting the key species to grow straight and tall. Trees of economic value such as mulberries and apricots are planted on the lee side to increase the thickness of the belt. In oases along the Hexi Corridor, *Populus cupidata and Eleagnus angustifolia* are usually planted in interior belts. In the northern Ulan Buh Desert, mixed plantings of *Salix matsudana prevail.* In oases on the rim of the Taklimakan, economic species such as mulberry, appricots and walnut are added to belts composed of *Populus bolleana, Populus nigra* L. var. *thevestina* and *Eleagnus angustifolia.*

Farmland protective belts are generally deployed along ditches or roads, often with one ditch between two belts. They are mainly loose and ventilating. Experience shows that shelter belts of mixed trees and shrubs with a loose structure are effective in areas seriously vulnerable to wind and sand, while in more ordinary conditions, belts of a ventilating structure with low wind penetration are preferable within oases. According to data obtained in southern Xinjiang under medium wind velocity, a shelter belt with a wind penetration coefficient of 0.5 or so has a protective range of 23.7 *H* with a wind-breaking effect of 34.41 per cent, while the sand content close to the ground is 60-70 per cent of that outside the network. Using interior belts of this type, the farm of the 150th Corps at Mosouwan in the south-west part of the Gurbantünggüt Desert has reduced the area endangered by wind and sand from 21 per cent of the total in 1961 to 1 per cent in 1978.

Shifting sands within oases may reappear with the destruction of vegetation on stabilized dunes or with sands supplied by dry riverbeds. The remedy can often be found as in Shache, Xinjiang, by planting trees around the dunes. In other places mechanical measures have been called for in addition to tree planting. At Jinta, Gansu, clay was placed on top of the dunes. At Minqin, Gansu, checkerboard clay barriers were constructed, inside of which sand-binding plants like *Haloxylon ammodendron* were established.

Combined tree-shrub-grass structures for fixing moving sands

In the sandy lands on arid and semi-arid steppes, annual rainfall which averages 200-450 mm and sometimes reaches as much as 500-600 mm establishes favourable conditions for stabilizing moving sands with vegetation. Here tilled lands are mostly distributed on valley terraces and wet lowlands interspersed with sand dunes in zigzag patterns. Here also, the tree-shrub-grass combination has been adopted to stabilize drifting sand in a variety of ways depending on local conditions.

Blocking in Front and Pulling from Behind

In the Mu Us sandy land, experience shows that planting *Salix cheilophila* and *Salix matsudana* saplings or poplar cuttings in depressions between dunes, forming woodlots on the lee slopes of barchan and dune chains, has the effect of blocking moving sand in front, for the dunes are thus partitioned and contained. On the lower one third of the windward slopes, plantings are made of such sandfixing species as *Salix cheilophila* or *Artemisia ordosica.* This has the effect of pulling the dunes from behind, since the vegetation cover lowers wind velocity at the ground surface, as shown in Table 5, and thus reduces the amount of sand blown off by the wind. Observations indicate that the sand content of the air declines as the cube of the decrease in wind velocity. Less sand is blown off the windward slope to accumulate on the lee slope. At the same time, the wind will blow the top of the dune away, and as its height is reduced, trees are planted which act to continue the levelling process until the dunes have acquired gentle slopes. As vegetation increases from less than 5 per cent to 50-60 and even 80 per cent, the dune can be said to be stabilized. This process, illustrated in Table 6, will generally take about five years. The people of the Mu Us sandy lands have applied the method with variations, as follows.

Table 5. Relative values between velocities at various heights of sand dunes with vegetation cover and those within 1.5 m on top of shifting sand dunes

Height (m)	Top of shifting sand dune (%)	Top of sand dune with vegetation cover (%)	Lowlands between dunes with vegetation cover (%)
1.5	100.0	90.0	52.8
0.5	87.1	57.1	34.2
0.2	72.8	54.2	30.0

Table 6. Relative values between wind velocities at various parts of barchan and that on the dune top (percentage)

Part of sand dune	Relative value of wind velocity
Lowland windward	76.7
Slope foot windward	77.9
1/3 slope windward	91.5
1/2 slope windward	94.7
Dune top	100.0
1/2 slope leeward	8.4
Slope foot leeward	27.0
Depressions between dunes	45.2
Lowland in front of windward slope of another dune	67.3

Note: Height of observation is 20 cm; dune is 5 m high.

1) *Drag from behind only*. A belt of *Salix cheilophila* is planted on the lower part of the dune's windward slope to let the wind do the levelling. As soon as comparatively level stretches are formed, shrubs are planted, and planting continues until the dune area is completely level and covered with shrubs. The method is called "chasing the wind and driving away sand with vegetation". It has been applied at Woduzaidang Brigade, Shenmu Country, Shaanxi, to stabilize moving sands.

2) *Block first and pull later*. Tall tree cuttings – of *Salix matsudana* or *Populus simonii* – or the shrub *Salix cheilophila* are planted in depressions behind the lee slopes of the dunes. Since the trees block the advance of the dunes, their tops will be levelled in two or three years time, when *Salix cheilophila* can be planted on the windward slope to stabilize the surface. This method was applied extensively by the people of Ejenhoro Banner, Inner Mongolia.

3) *Mixtures of trees and shrubs* have been planted to stabilize low dunes (below 7 m) scattered over wet lowlands or undulating sandy land. Trees such as *Salix matsudana* or *Populus simonii* are planted in depressions between the dunes, while trees planted on the lower part of the windward slopes are screened against the wind by such shrubs as *Artemisia ordosica* and *Salix cheilophila.* The artemisia will be removed after two or three years to benefit the growth of the trees, as was done on the May 7th Forest Farm in Ejenhoro.

4) *Tree-shrub-grass combination.* This is a method that developed out of "block in front and pull from behind" by adding herbs and grasses, such as *Melilotus albus,* planted in depressions between dunes, among other places, at Yangjianghao, Chengchuan Commune, Otog Banner, Inner Mongolia.

In all the foregoing methods, shrubs are planted on windward slopes to provide shelter against sand deflation. Data collected in northern Uxin Banner show that 20 cm above the surface, winds are down to 74 per cent of those blowing over unprotected dunes where *Artemisia ordosica* was planted five or six years before. Branches fall from artemisia, increasing the fertility of the soil and encouraging the growth of other herbs. At Dingbian, Shaanxi, in the southern part of the Mu Us sandy land, a crust formed on the sandy surface after *Artemisia ordosica* had been in place for three or four years, and in eight to ten years, the content of organic matter in the 0-50 cm surface layer had increased from 0.17-0.33 to 1.42-1.48 per cent.

Under the protection of such shrubs, the finer sands are no longer blown away. Within five or six years, particles of 0.01-0.05 mm diameter in the 0-5 cm surface layer had increased from an original 1.28 to 7.56 per cent.

It should be pointed out, however, that the planting of *Artemisia ordosica* will tend to dry out the sand dunes because the root system absorbs a considerable amount of moisture. Data collected in late May show that on dunes planted with artemisia, the moisture content at a depth of 5-20 cm had dropped from 5.56 per cent before planting to 4.93 per cent after planting. The drop in moisture was even greater below 20 cm. This is detrimental to the growth of trees. Therefore, saplings should be planted shortly after the barriers of artemisia are in place. The artemisia barriers are best established in autumn when the moisture content of the soil is comparatively high and the wind not so strong, with the trees planted in the following spring. In some districts, the artemisia is removed after it has performed its protective function and replaced with other selected species. At Hele, Ejenhoro Banner, *Salix cheilophila* and *Artemisia ordosica* were planted in alternate rows, with the former protected by the latter. The artemisia was removed when the willow shrubs had matured and was replaced by *Pinus sylvestris* var. *mongolica* or *Pinus tabulaeformis,* under the protection of the *Salix cheilophila. Amorpha fruticosa* can also be used to stabilize drifting sand and improve sandy soil. Data show that five years after planting the organic content of the surface layer had increased by a factor of four.

Tree Shrub Combinations for Transforming Sand Dunes into Woodlands.

Parts of the steppe are favourably endowed with water. The best such region is the Horqin sandy land with an annual rainfall of 300-600 mm and a moisture content of 3-6 per cent in the sand strata. Under such conditions, it is possible to establish patches of trees in the depressions between dunes, while simultaneously planting sand binders, mainly shrubs, on the dunes preliminary to the establishment of the pine groves forming woodlands. Suitable species for the depressions between dunes are *Populus simonii, Populus pseudosimonii, Amorpha fruticosa* and *Salix flavida.* Where the water table is 2-3 m deep and no water-logging appears during the rainy season, *Pinus sylvestris* var. *mongolica* and *Pinus tabulaeformis* may be planted with other trees.

In the Jangutai District, Zhangwu, Liaoning Province, the measures taken to stabilize dunes began with the construction of artificial barriers on the lower two thirds of the windward slopes. Below the barriers, *Artemisia halodendron* or cuttings of *Salix flavida* are usually planted, although belts of *Lespedeza dahurica* or *Caragana microphylla* can also be used for the same purpose. Sand-fixing plants should be established after the top of the dune has been blown away. After two or three years, when the surface is relatively stabilized, is the time to plant pines between the shrubs or herbs on the dunes. Earlier planting would leave the saplings vulnerable to wind scouring or sand burial, while in later plantings the growth of pine saplings is affected by the absorption of a large amount of soil moisture by the root systems of the shrubs. Since *Pinus sylvestris* var. *mongolica* develops a strong root system in dry, poor soil with deep vertical and large horizontal roots which facilitate the absorption of nutrients and moisture, it is the favoured species for afforestation on sandy land in arid steppes.

These were precisely the procedures through which moving sand dunes near Jangutai in the south-eastern part of the Horqin sandy land were transformed into pine-covered sandy soil with significant changes in the local landscape. The forest now has an average height of 7 m, in places as high as 10 m, with trunks an average of 12 cm in diameter and the largest 24 cm. At a height of 1.5 m within the forest, wind velocity has decreased by 78.4-81.2 per cent compared with the wind velocity in open terrain.

Experiments with enclosures to protect vegetation cover

If the vegetation cover is to be protected on sandy land, the ground surface must be protected against wind erosion and the reappearance of moving dunes, while young trees and crops must be guarded against sand movement and damage from wind and wind-blown sand. Vegetation cover works within enclosures formed by the shelter belts to provide such protection.

In the northern part of the Ulan Buh Desert in Inner Mongolia, sandy lands sown to shrubs such as *Artemisia ordosica* and *Nitraria* spp. have achieved a vegetation cover of 50-60 per cent with adequate irrigation. Dunes with less than 5 per cent cover in the Ulan Buh near the Dengkou oases have become semi-fixed mounds with a 20-30 per cent coverage of shrubs.

In the oases on the fringes of the Taklimakan and along the Hexi Corridor, it has become the customary practice to plant *Tamarix chinensis* on sand dunes to turn them into shrub-covered mounds which, as experiments show, have the effect of checking the drift of sand. Observations made at Shache on the edge of the Bukuli Desert show that at the surface of a mound covered with tamarix, wind velocity is generally 40-50 per cent lower than it is on naked sand, while the sand content of the wind is 80-90 per cent less. Planting herbs on enclosed sandy land has been further developed at Turpan in recent years by winter irrigation and by sowing grasses inside the enclosed area. The result is an average increase of seven new seedlings per square metre and a vegetation cover of 60-85 per cent within three years. Shrubs suitable for enclosed areas include *Alhagi pseudalhagi* to be mixed with *Karelinia caspica* and *Crespis* spp. On undulating sand surfaces on the fringes of oases, *Phragmites communis, Tamarix chinensis* and *Halostachys belangerinna* are used where the water table and mineralization are both high, while *Capparis spinosa* is more suitable to wind-eroded land. A surface covered with 80-85 per cent *Alhagi pseudalhagi* is shown by observation to be over 40 times as rough as the wind-eroded surfaces outside, while the surface wind velocity is 50.5 per cent lower, as shown in Table 7. This causes the coarser sand particles to settle down. The windward face of the

Table 7. Changes in surface wind velocity and ground surface roughness brought about be enclosure experiment with herbal vegetation (Aitinghu People's Commune, Turpan)

	Ground surface wind velocity (m/sec)	Relative value of wind velocity (%)	Ground surface roughness (cm)	Relative value of roughness (%)
Wind eroded land outside oasis	9.0	100.0	0.0344	100
Sandy grounds with 85 per cent coverage of *Alhagi pseudalhagi*	5.0	50.5	1.360	3,953

shelter belt becomes a sand trap, minimizing sand accumulation within the shelter belt and benefiting the growth of young plants. The ability of vegetation to halt sand movement within fenced enclosures is all the more evident where water conditions are fair as in the dunes in the north-eastern part of the Mu Us sandy land. There the natural vegetation, mainly *Artemisia ordosica,* achieved a 60-70 per cent cover in four to five years time, and fine sands of a size below 0.05 mm have increased by 50 per cent while organic content has risen from an original 0.079 to 0.71 per cent.

The grass kulum to block wind and sand and to create pastures

The management of sandy lands on arid and semi-arid steppes has two aspects. On the one hand, it seeks to remedy the damage caused by drifting sand and to halt movement of dunes. On the other hand, it aims to take advantage of local water, land and vegetation resources to rehabilitate pastures and develop animal husbandry. The Uxinju People's Commune, Uxin Banner, Inner Mongolia, has shown that building grass kulums is an effective measure for preventing damage from drifting sand, for protecting, managing and rationally utilizing pastures, and for building sustained high-yield fodder bases.

Different conditions in the Uxinju sandy flats have called for different treatment, in terms of which grass kulums can be classified in three types:

1) *The tree-shrub-grass combination kulum for sand control.* This type of kulum is generally built in areas of moving and semi-stabilized dunes where measures to control sand primarily make use of sand-fixing vegetation. The goal is to turn the dunes into producers of fodder.

For barchan and barchan chains of a height less than 10 m rows of *Salix cheilophila* are planted on the lee side of the dunes, in certain areas combined with such natural shrubs as *Salix microstachya* and *Hippophae rhamnoides* to form dense shelter belts as a block against advancing sand. On the lower one half to one third of the windward slopes where sand has a little moisture and the wind is not strong enough to endanger survival, *Artemisia ordosica* is planted against the main wind direction. As the vegetation cover increases and weakens the wind force so that the sand on top of the dune is no longer carried away, artemisia is extended up the slope until the whole dune is covered and wind erosion checked, a process that requires from three to five years.

In order to prevent wind erosion gaps caused by withering of the artemisia in seasons of drought and strong wind, various precautionary measures should be taken. For instance, *Artemisia ordosica* and *Salix cheilophila* should be planted in rows, and in the first two years care should be taken to replace dead shrubs promptly with young saplings so as to leave no wind gaps. The shrubs should be protected against cutting and grazing for three years to five years after the planting so that the canopy can be closed as quickly as possible.

To control undulating dune lands and the flat sandy lands on the fringes of wet lowlands, cuttings of *Salix matsudana* are planted to form forests. Tall cuttings three to four years old and about three metres long should be planted deep, up to one third of their length. If the water table is more than one or two metres below the surface, the bottom ends of the cuttings should be immersed in water for 10 to 15 days before planting so as to improve survival chances during seasons of drought and wind. Suitable planting distances between trees and rows are 5 x 5 m or 3 x 4 m. In such cases, the canopy should be closed within three years. But if *Salix matsudana* is planted on the windward slope of dunes, the root system must be protected from exposure to wind erosion by adding *Salix cheilophila* and by sowing grasses. In one system, three species are planted in alternate rows, with *Artemisia ordosica* protecting *Salix cheilophila,* which protects, in turn, the *Salix matsudana* saplings. This has proved to be a satisfactory way of avoiding wind and sand scourge.

2) *Grass kulums for hay and winter-spring grazing.* Kulums of this type are in general built on inter-dune lowlands and lake basins in sandy areas. They are a type extensively distributed at present, mostly on slightly saline meadow soils or on clay meadow soils, with vegetation cover composed of various types of mesophytes and hygrophytes forming meadows adapted to slight salinity. Such, for example, are *Achnatherum splendens* saline meadow, *Iris ensata* saline meadow, sedge-forb meadow,

grass-forb meadow and reed-forb meadow, with the reeds consisting of *Phragmites communis*. As a result of fencing, protection and rational use, the vegetation cover improves very rapidly in grass kulums of this type, with density and height as well as coverage increasing markedly. On wet lowlands, the yield of palatable gramineous grasses such as *Aneuolepidium dasystachys* in air-dried matter is 1.37 times prior to fencing and protection. At the same time ground litter from the rank growth of grasses prevents the reappearance of moving sands while improving the organic content of soil. Enclosures are equally effective on sandy pastures, as shown in Table 8.

Table 8. Effects of an enclosure programme on sandy pasture (Uxinju Commune)

Plant community	Condition	Vegetation coverage (%)	Height of shrubs and subshrubs (cm)	Height of herbs (cm)	Weight of air-dried matter (g/100 m^2)	Years under enclosure
Artemisia ordosica +Hedysarum mongolicum-annual	Closed and under protection	60	66	4	6,979	8
	Degenerated	25	44	3	2,031	

3) *Water-grass-forest-cereal, four-in-one grass kulum*, an improvement on the second type, might be considered as a new stage of comprehensive treatment. The four-in-one is usually built in depressions between dunes where the land is flat, water plentiful and the soil mostly of sandy clay meadow rich in organic matter. These new kulums are generally developed in the following four stages:

a) Ground water is brought into use in ways that depend on local conditions. Shallow ground water can be tapped with large mouth wells or pipe wells. The former is a ditch-like reservoir three metres deep that collects ground water by seepage and is dug with a view to expanding the irrigation area of a single well. The pipe-well will be 20 to 30 metres deep with a strong cement pipe 50 cm in diameter serving as the shaft, the wall of which is of a type that permits water percolation and prevents shifting sand from clogging the shaft. Deep water can be tapped with pumps or artesian wells, accompanied by measures to conserve the water.

b) Shelter belts of trees and shrubs – *Salix matsudana* and *Salix cheilophila* – are planted at right angles to the prevailing wind in the form of narrow belts of loose construction which not only prevent sand drift but also provide leaves and twigs for fodder. Additional sowing of plants such as *Melilotus albus* in tree and shrub patches near sand dunes helps to check the wind and prevent damage from sand.

c) Land configurations are modified, including the levelling of dunes and the filling of depressions between them. The soil after cultivation improves greatly both in weight per volume and improved porosity.

d) Selected species of pastures and cereal crops are planted, including *Melilotus albus, Medicago sativa, Sorghum sudanense* and *Astragalus adsurgens*. These are not only of higher yield and nutritional value than natural range species, but they also help to improve soil quality, as shown in Table 9. Cereal crops such as *Panicum miliaceum* and *Hordeum vulgare* var. *nudum* are also cultivated, and nurseries are set up. In the advanced four-in-one grass kulum of the Zhahanmiao Production Brigade, 5 per cent of the total acreage is devoted to growing selected grasses and cereal fodders, 30 per cent to improved natural hay, 60 per cent to pastures, and 5 per cent to forest land and other uses. Kulums of this type have come to play the major role in reclaiming and improving the grasslands, and are increasing at a rapid rate.

The kulums established in the Uxinju People's Commune have been effective in controlling damage from sand and wind and in rehabilitating the steppe lands.

Table 9. **Effects of *Melilotus albus* on soil (Uxinju Commune)**

	Organic matter (%)	Nutrients (%)			Porosity (%)	Volume weight (g/cm³)
		N	P	K		
Inter-dune grounds planted with *Melilotus albus* for 2 years	1.138	0.046	0.168	2.58	50.5	1.31
Inter-dune grounds without planting *Melilotus albus*	1.018	0.040	0.074	. . .	44.0	1.48

Weakened wind and sand activity

After fixing moving dunes with vegetation, observation shows that the ground surface is 290 times as rough as it is on naked dunes, and both the velocity of the wind and its sand content within 20 cm of the surface have registered remarkable drops, as shown in Table 10. On inter-dune ground planted with *Salix cheilophila* and hedged-in shrubs, density of vegetation cover is as high as 75 per cent and the surface roughness is 617 times that of untreated dunes. Here the reduction in wind velocity and sand content is most apparent and the effects of vegetation most obvious.

Table 10. **Effects of vegetation cover on shifting sand dunes in respect of surface wind velocity and sand content in air current (Uxinju Commune)**

Type of ground surface	Vegetation coverage (%)	Relative value of wind velocity (%)	Reduction of wind velocity (%)	Relative value of sand content in air current (%)	Reduction of sand content ((%)
Shifting sand dunes untreated	below 5	100.0	. . .	100.0	. . .
Dunes planted with *Artemisia ordosica* and *Salix cheilophila*	28-50	74.3	25.7	4.8	95.2
Inter-dune grounds planted with *Salix cheilophia* and hedged-in natural shrubs	75	37.2	62.8	2.3	97.3

Note: Height of observation 0 - 20 cm above ground.

Changes in soil properties

Consider sand dunes stabilized with *Salix cheilophila* and *Artemisia ordosica*. By comparing these with untreated dunes down to a depth of 20 cm, it is seen that particles smaller than 0.05 mm have increased from 3.31 to 15.38 per cent, while the soil's weight per volume dropped by 0.12 g/cm³, porosity increased by 4.4 per cent, dry soil aggregates larger than 1 mm in diameter increased by 7.6 per cent, and organic matter content increased from 0.098 to 0.168 per cent, as shown on Table 11. Considerable changes also took place in the content of the nutrients.

Table 11. Changes in surface soil properties after adopting vegetative sand-binding measures at Uxinju People's Commune

	Particle size . <0.05 mm (%)	Volume weight (g/cm^3)	Porosity (%)	Dry aggregate . >1 mm (%)	Organic matter (%)	Nutrients (%)		
						N	P	K
Shifting sand dunes	3.31	1.69	36.2	0.2	0.098	0.033	0.05	2.82
Dune stabilized with *Salix cheilophila* and *Artemisia ordosica*	15.38	1.57	40.6	7.8	0.168	0.063	0.060	3.00
Sand dunes in high forests	6.33	1.61	39.2	' '	0.141	0.040	0.087	2.90

Notes: Sampling depth: Organic matter and nutrients: 0-15 cm; mechanical composition and dry aggregates: 0-20 cm; volume weight and porosity: 0-10 cm. Years of sand fixation: 6

Improved pastures

The quality of the vegetation composition inside the kulum is much superior. Grasses in the reed-plus-forb community have come to constitute 42.7 per cent of the biomass by weight and leguminous herbs 34.6 per cent, while poisonous weeds are down to 2.8 per cent compared with a striking 84.6 per cent on deteriorated pasturelands where, too, gramineous vegetation is a mere 6 per cent. Secondly, there is a marked increase in plant height, growth within the kulum averaging 11 times higher than that outside. Thirdly, the density of vegetation has increased. The reed community has achieved a cover of 90 per cent, while the sedge-forb community has reached 75 per cent, as compared respectively with 15 and 20 per cent on degenerated pasturelands. Finally, the hay yield has greatly increased. On one grass kulum begun at Uxinju in 1964, hay yield is 19 times what it is on degenerated pasturelands.

Such changes indicate that the grass kulum is a tested and effective method for stabilizing dunes, for improving soil and the growth of forage, for building up pastures and developing animal husbandry.

Engineering measures combined with vegetative methods to protect roads

With the development of the People's Republic of China, more and more roads and railroads are coming to run through desert areas. Routes are carefully selected so that transportation will not be interrupted by desert conditions. Depending on different local conditions, engineering measures as well as vegetative methods are employed to keep roads and railroads in smooth operation. In some cases, routes are menaced by the movement of dunes, in others by drifting sand, in still others by both. These circumstances call for different responses.

For railway lines running through steppes with drifting sand and fixed and semi-fixed dunes: Temporary engineering measures, such as building barriers against drifting sand, are undertaken during construction. Other means must be used for the more permanent protection of the roadbed, such as sodding the slopes of the roadbed with grass turf obtainable from nearby depressions between dunes, enclosing sandy areas on both sides of the road to protect vegetation and let it grow, and planting sand-fixing vegetation on dunes.

Along railway lines in the Horqin sandy land, measures to stabilize sand have been graphically portrayed by the people as follows: *Artemisia halodendron* as the sand binder; *Caragana microphylla* as a hat for the dune; *Lespedeza dahurica* as its apron on the windward slope; poplars as its boots – for the foot of the dune and for the depressions between dunes; and *Salix flavida* as its shawl for the lee slope. Thus is formed a protective system called "the right tree for the right place"

Where sufficient water is available, trees such as *Pinus sylvestris* var. *mongolica* and *Pinus tabulaeformis* may be planted on sand dunes. To stabilize sand along railroad lines, the surface should first be fixed by building straw grids or rows of vertical barriers on moving dunes and then between the barriers to establish such sand-fixing plants as *Salix flavida, Artemisia halodendron, Caragana microphylla* and *Pinus sylvestris* var. *mongolica.* Two years after such measures were undertaken on shifting sand dunes north-east of Naiman in the central Horqin sandy land, the density of the vegetation cover on the dune surface had increased from the former 3 to 30-40 per cent.

For railway lines running through desert borders where moving dunes stretch and undulate: An example of this situation can be found in the Zhongwei-Gantang section of the Baotou-Lanzhou Railway on the south-eastern fringe of the Tengger Desert. Here gravel protection is provided on the slopes of the roadbed and gravel platforms established on both sides of the line. In addition, protective belts have been built on both sides of the line for distances proportional to the movement of the dunes. Thus, on the side facing the main wind direction, the belt is 500 m wide, while a belt of 200 m width has been established against the secondary wind direction. The belts consist of barriers of straw arranged in a checkerboard pattern. Observations carried out after construction show that straw grids make the ground surface 220 times as rough as the surface of untreated dunes and the surface velocity of the wind is 23 per cent less while its sand content is conspicuously lower, 84 per cent less with a wind of 8 m/sec.

As the straw barriers check sand flow on the dune surface, sand-fixing plants within barriers have better chances of survival and growth. With the fairly stable surfaces provided by the checkerboard pattern, it is possible to introduce shrubs to stabilize dunes on their windward slopes, where a moist layer lies 3-20 cm below the dry surface with a water content of 2-3 per cent, a wilting coefficient of 0.7 per cent and water available to the plants of 1.3-2.3 per cent. This layer gets replenished during the summer-autumn rainy season. Experience at Shabodou on the Baotou-Lanzhou Railway shows that *Hedysarum scoparium* has the highest survival rate and the best growth and that *Caragana korshinskii* exhibits fairly steady growth. Next best are *Calligonum mongolicum* and *Salix flavida.* As a result of such measures, moving dunes have become semi-fixed and density of vegetation cover has increased from a previous 3 to 14.3 per cent, in some areas to 25 per cent, ensuring the smooth operation of the Baotou-Lanzhou line as it traverses the south-east Tengger Desert.

High-lift pumping-irrigation projects have been built in the Shabodou District to pump water from the Yellow River for reclaiming sand dunes, and for making terraces and watering them for the benefit of afforestation. Years of experience have shown that rows of trees should alternate with rows of shrubs in irrigated afforestation projects. Among preferred trees are *Robinia pseudo-acacia, Eleagnus angustifolia, Populus cupidata* and *Hedyscoparium, Caragana korshinskii, Salix flavida, Amorpha fruticosa* and *Salix cheilophila* are the shrubs of choice. There is generally enough silt in Yellow River water that it will settle in the irrigated area and within a year form a crust on the sand, thus fixing it and offering the trees under irrigation a higher survival rate and quicker growth.

For railway lines running through arid zones and gobis where wind and sand drift are severe threats: The Yumen section of the Lanzhou-Xinjiang Railway illustrates such a case. During construction, temporary measures were adopted such as combinations of ditches and banks. More permanent protection is provided by irrigation canals lined with rows of trees and shrubs, preferably *Populus cupidata, Eleagnus angustifolia and Salix cheilophila,* with the last deployed on the windward side to check drifting sand. The effect of this arrangement on the wind is shown in Table 12. It should be pointed out that as the shelter belts here are mainly for protection against burial of the roadbed by sand, they should generally be of a dense structure. At wind gaps where the drift of sand is strong, two to three rows of barriers should be placed in front of the shelter belt to block sand encroachment. In view of the gravelly character of the gobi, care should be taken to ensure tree survival by planting

Table 12. Wind-breaking effect of railroad protection by forest against sand

	Wind velocity (m/sec)	Relative value (%)
Open field	11.4	100.0
2.5 H	6.4	56.1
7.0 H	7.7	67.5
10.0 H	9.0	79.9

the saplings in ditches in good soil which has been brought in. Water seepage should be prevented by lining the ditches with mortared pre-fabricated cement slabs. As a result of these measures, the length of the Yumen section of the Lanzhou-Xinnjiang Railway under threat has declined from an original 94.7 per cent to a current 2.7 per cent.

For highways passing through desert areas: Where conditions are favourable for sand-fixing plants, forest belts can be planted along roadways and dunes fixed by planting shrubs such as *Artemisia ordosica* and *Salix cheilophila,* with trees and shrubs properly combined. Where dunes are fixed or semi-fixed, the easiest procedure is simply to fence them and let the grass grow and provide vegetation cover. This method has been widely used on most highways in the Mu Us sandy land. In areas where vegetative fixing is not practical, great care should be taken to select favourable routes, as on river-beds in deserts, in the bottleneck sectors of lake basin sand dunes, or on open inter-dune grounds between large sand hills where the rate of sand advance is low. Meanwhile, sand damage should be minimized by streamlining the road-bed sections formed of shallow troughs and wind banks for transporting sand, by elevating the road-bed above the average height of the surrounding dunes, and by paving a solid, even and smooth surface which will easily shed sand.

In addition, comprehensive engineering measures should be undertaken on both sides of the road to fix, block, transport and guide away sand by building sand barriers on the road's windward side, by covering nearby dunes with pebbles or salt blocks obtained in the vicinity, by establishing checkerboards of reeds to increase surface roughness to reduce wind velocity and the amount of wind-blown sand, and by building banks and wind-guiding panels close to the road to prevent sand from accumulating.

Observations made on desert highways in the mouth of the Taklimakan show that streamlined road surfaces together with rows of wind-guiding panels are effective in preventing the road surface from being buried by sand. Streamlining provides a smooth flow while the panels increase surface wind velocity (at the lower exit of the panel, the wind is moving 1.6 times as fast as in front of the panel in the open field) which blows the sand across the road without allowing it to accumulate. To fix sand dunes and prevent them from advancing toward the road, both reed and pebble barriers are fairly effective.

Building farmlands by levelling sand dunes with water

This method is used extensively in Yulin District in the southern part of the Mu Us sandy land and in Yangbian District, where it has been turned to fullest account. Levelling out sand with water requires that water be led naturally or drawn mechanically from rivers, lakes or reservoirs to level dunes on riverbanks or on terraces so as to convert undulating ground into flat and even sandy farmlands. Since large quantities of water are required for this task, ample sources must be available and water conservation applied. In certain districts, floodwaters are used to level out sandy lands. It takes 2,450 cu m of water to level one *mu* of land, each cubic metre of sand needing 2-2.5 cu m of water. (One *mu* = 1 are = 1/100th hectare.)

Once the land is levelled, other measures for soil imprevement should be taken, such as flooding, covering infertile land with "guest" soil and planting green manure. Such action should be taken in combination with water conservation projects and shelter belts to turn barren earth into fertile farmland. The experience of the Yangjiaoban Production Brigade in Jingbian Country, Shaanxi Province, shows that as a result of flooding with water, tilling, applying fertilizer and cultivation, conspicuous changes appeared in the physical and chemical characteristics of the sandy soil as shown in Table 13. Before any soil improvement was undertaken, the mechanical composition of the drifting sand consisted of fine particles 0.25-0.05 mm in diameter. In the sandy layer within 25 cm of the surface, the content of fine sand was as high as 82.2-88.8 per cent, while clay particles smaller than 0.001 mm in diameter accounted for only 4.4-6.4 per cent. Following a number of years of soil improvement, the fine sand content of the surface layer had dropped to 7-17 per cent, while the silt content of particles 0.05-0.001 mm in diameter had increased to 63-70 per cent. The balance, or 16-20 per cent, had come to be made up of clays of less than 0.001 mm in diameter.

Table 13. Changes in mechanical composition (in percentages) of sand soils after levelling out sand with water (Yangjiaoban Production Brigade, Jingbian Country)

	Sampling depth (cm)	Particle size (mm)					
		1-0.25	0.25-0.05	0.05-0.01	0.01-0.005	0.005-0.001	Less than 0.001
Shifting sand dune	0-5	9.46	82.23	0.66	0.52	0.60	6.43
	5-25	2.70	88.77	2.91	0.61	0.61	4.40
10 years after treatment	0-12	4.13	17.14	47.59	9.83	5.49	15.82
	12-13	2.42	7.38	54.70	23.69	2.29	9.52
20 years after treatment	0-15	1.98	7.72	54.90	7.71	7.71	20.08
	15-40	12.98	66.82	9.65	5.26	0.60	4.69

Table 14. Changes in nutritional content in sand soil after levelling out sand dunes with water

Years after treatment	Sampling depth (cm)	Organic matter (%)	Total amount of nutrients (%)			Available nutrients (mg/100 g soil)		
			N	P	K	Water soluble N	P_2O_5	K_2O
I	0 - 13	0.214	0.026	0.064	1.57		1.1	9
	13 - 24	0.086	0.063	0.042	1.07	3.79	1.1	7
	24 - 50	0.064	0.016	0.006	1.56	2.38	1.2	6
II	0 - 26	0.706	0.042	0.076	1.66	3.70	0.9	17
	26 - 49	0.278	0.037	0.030	1.18	3.44	0.7	8
17	0 - 14	0.814	0.071	0.088	1.86	5.82	1.3	21
	14 - 30	0.788	0.087	0.082	1.94	5.29	0.8	20

Just after levelling, sandy lands are poor in nutrients, averaging around 0.09-0.21 per cent and nitrogen content 0.02-0.06 per cent. After ten years of improvement, the organic content had increased to 0.7-0.8 per cent and total nitrogen content to 0.04-0.08 per cent with a corresponding increase in other available nutrients, as shown in Table 14. As a result, grain yield per *mu* increased from 50-60 *jin* to 650-odd *jin*.

During recent years, new soil improvement measures have been developed in semi-arid areas in northern Shaanxi by planting rice on new sandy lands, which not only put an end to sand drift but also improved the quality of the soil by the fine mud and organic matter contained in the water. Physical survey data on soil improvement by raising paddy rice on sandy flats were gathered by the Yuhebao Farm, Yulin County. They show that under dry farming, the soil weighed 1.697 g per cu cm with a porosity of 33.4 per cent and with 59 per cent of it composed of particles smaller than 0.05 mm in diameter. After the land had been turned into paddy fields for four consecutive years plus one year for dry crops, the soil weighed 1.449 cu cm with a porosity of 43.6 per cent and particles smaller than 0.05 mm then constituted 77 per cent of it. As a result of applying large quantities of manure and decomposed paddy roots to the paddy soil, the content of organic matter rapidly increased and expedited the manturity of the soil, thus turning barren sandy fields into farmlands with a high and sustained yield.

In northern Shaanxi in more recent years, this method has been further developed by building canals and weirs, the latter being dams made by sand deposited from water flow, and by watering the sand in order to turn the area green. Weirs have become very popular in the steppe region, where a number of reservoirs have been built. They Yudung Canal, besides supplying water for normal irrigation purposes, discharges its surplus water on sandy fields, and in the course of six to seven years, the whole district has been basically protected from damage by sand.

Building Water Conservation Projects, Reclaiming Barren Lands, and Improving Soil to form New Oases

A number of deserts are located in intermontane basins surrounded by snow-capped peaks, whose run-off feeds such rivers as the Yarkant, Hotan, Aksu, Manas, Shule and Hei with their sources in the Kunlun, Tian Shan and Qilian mountains. By opening canals lined with pebbles or cement to prevent seepage and to lead water into the desert, and by building reservoirs on inter-dune depressions and lakes on lowlands along rivers to conserve floodwaters, barren lands on the desert's edge and along rivers in the desert may be reclaimed. Action directed toward providing water should be combined with soil improvement and the construction of shelter belts. A number of measures can be taken to improve the soil.

1) *Using floodwaters for irrigation.* Since floodwaters contain large amounts of clay and a certain amount of nitrogen, they improve the soil and increase its fertility. Test data obtained at the Dengkou no. 1 main canal in the eastern part of the Ulan Buh Desert show quantities of nitrogen as follows: in ammonia, 0.1-0.5 g/cu m; in nitrous form, 0.1 g/cu m; in nitrite form, 0.1-1.148 g/cu m. Moving dunes along the Yellow River in the Shabodou District, Zhongwei County, in the south-eastern part of the Tengger Desert, were levelled, inundated, fertilize and cultivated. Within eight years' time, the content of organic matter had increased from 0.0778 to the current 0.657 per cent.

2) *Adding sand to improve soil structure.* In the process of flooding newly reclaimed lands, attention must be paid to limiting the thickness of the silt layer, for too much silt results in crusting, poor permeability and rapid evaporation, all of which are detrimental to plant growth. On the other hand, some barren lands are composed of clay. In either case, addition of sand is called for. According to the experience of the 150th Corps Farm, Shihezi, Xinjiang Uygur Autonomous Region, adding sand to clay can break up crusting, cause the weight of the soil to drop by 0.14 g/cu cm, porosity to increase by more than 10 per cent, and the salt content in the surface layer (to 10 cm deep) to drop by 0.7 per cent. Moisture is preserved and the water content in the surface layer increased by 3.5 per cent.

3) *Cultivating green manure,* such as sweet clover, alfalfa and *Astragalus adsurgens,* is another effective way to improve the soil of newly reclaimed desert lands so as to develop agriculture and

Table 15. Changes in content of organic matter and nutrients in soil after sowing alfalfa on inter-dune lowlands

	Sampling depth (cm)	Organic matter (%)	Total amount of nutrients (%)			Available nutrients (mg/100g)		
			N	P	K	P_2O_5		K_2O
Land without alfalfa	0-15	0.038	0.045	0.086	1.16	1.62	1.12	22.9
	15-60	0.557	0.033	0.138	2.05	1.74	0.50	57.6
Land with alfalfa	0-12	0.901	0.051	0.128	1.63	1.51	1.76	40.0
	12-35	0.523	0.045	0.158	1.93	3.51	1.62	51.8
	35-85	0.564	0.042	0.172	1.54	3.89	1.68	63.1

animal husbandry. Experimental data accumulated by a farm in the south-western part of the Gurbantünggüt Desert show that soil fertility was greatly increased by three years of growing alfalfa and then ploughing it under. This led to an accumulation per mu of 57.6 jin of nitrogen, 10.9 jin of phosphorus and 16.5 jin of potassium, equivalent to the application of 20,000 jin of high quality, stable manure. It was thus highly effective in stepping up subsequent yields, cotton increasing 3.14 times and winter wheat 2.78 times. When the inter-dune low-lands were sown to alfalfa in the Pingquan People's Commune, Linze District, in the Hexi Corridor, damage caused by drifting sand was stopped and the quality of the soil improved. As shown in Table 15, the organic content in the surface layer down to 12 cm depth increased to 0.901 per cent as compared with the former 0.038 per cent. Planting such green manure on newly reclaimed sands not only improves soil structure and steps up fertility but also increases the yield of fodder grass. On a farm in the south-western part of the Gurbantünggüt Desert, the area sown to alfalfa usually takes up 26 per cent of the total area under cultivation. This illustrates the importance with which this measure can be regarded as a means of improving agriculture and animal husbandry as well as guarding against wind erosion and sand damage.

4) *Remedying alkalization and salinization.* Secondary alkalization-salinization is a problem often encountered in dryland reclamation. It calls for a sound irrigation and drainage system to wash the salts out of sandy land. Since this is well known, it need not be discussed in detail here.

Transformation and Utilization of Gobis

Gobis in China spread over vast areas of desert and dryland. They are composed of piedmont diluvial or diluvial-alluvial gravels as well as of denuded detritus. As to their utilization, gobis of diluvial or diluvial-alluvial gravels as well as of denuded detritus. As to their utilization, gobis of diluvial or diluvial-alluvial type may be transformed into orchard or forest with appropriate measures. Experience at Turpan indicates that the following measures are necessary. First, mountain snow water or spring water is tapped for irrigation through canals lined with gravel, mortar and cement to prevent seepage. Second, loose protective networks of narrow shelter belts are built by planting trees in ditches dug along water channels or roads. In the vineyard at the Red Willow River Farm at Turpan, for example, the protective network is composed of shelter belts each 10 m wide, with main frontal belts 100 m apart, secondary belts 200 m part, and inner belts both main and secondary 200 m apart. The forest occupies 16 per cent of the total vineyard acreage and affords the vines effective protection from damage by wind and sand. Third, the land must be levelled and soil quality improved within the networks of protective forest. Experience shows that the preferable method consists of levelling strips of farmland along contour lines on slopes, building earth dikes before reclamation, and watering the soil so that coarse gravels accumulate against the dikes, thus building up strips of height. The next step is to dig planting ditches 5-10 m apart, each 40 cm in depth and 40-60 cm wide at the bottom. Where salt is found, it should be washed until the rooting layer is free of crystals. Pits 90-100 cm deep, 60 cm long and 40 cm wide should be dug at regular intervals on the bottom of the ditches, and these should be filled with guest soil mixed with compost. Grapevines are then established in the pits and watered. The use of guest soil, brought in from other areas, works conspicuously to improve the gobi soil, as shown in Table 16. It also decreases the content of coarse particles and increases the proportion of fine sand and clay, as shown in Table 17.

Table 16. Effects of guest soil on organic content of vineyards established in gobis (Red Willow River Farm, Turpan)

	Per cent
Gobi soil in the open	0.44
Ground soil between rows of grapevines	1.71
Soil in planting pit	2.35

Table 17. Effect of guest soil on changes of particle composition in gobi soil (Red Willow River Farm, Turpan)

Soil type	Sampling depth (cm)	Particle composition (mm) (%)							
		over 1 mm	1-0.25	0.25-0.05	0.05-0.01	0.01-0.005	0.005-0.001	Below 0.001	Loss of weight in HCl washing
Pit	00-2.5	47.69	14.29	10.58	7.45	3.26	4.98	3.64	7.11
	2.4-415	64.95	3.87	20.79	4.30	0.31	0.50	1.22	4.06
	41.5-63	65.52	8.19	9.31	6.51	2.09	3.75	2.80	1.83
	63-100	50.93	21.16	18.45	2.29	0.25	2.13	2.99	1.90
Open gobi	00-4.5	67.75	18.20	3.71	3.53	0.51	0.83	0.96	4.51
	4.5-38	74.67	12.14	6.65	1.04	0.34	0.73	1.09	3.34
	38-47	46.40	32.16	10.34	2.13	0.59	1.91	1.95	4.12
	47-85	70.49	12.93	6.73	3.17	0.81	2.65	1.41	1.81
	85-100	76.90	6.08	8.10	1.12	0.18	2.31	1.35	3.36

Under normal circumstances, grapevines begin yielding fruit after three years, and in five years' time cover up to 80-95 per cent of the ground surface, thus controlling wind and sand damage. In Turpan, over 20,000 *mu* of gobi have been turned into productive vineyards.

Trees grown on gobis not only provide crops with protection but can also supply lumber. In the experience of the people in Hexi Corridor, trees are planted in gobis by establishing seedlings in pre-dug ditches – at Linze, these are 1.5 m wide and deep – which facilitate irrigation and promote the growth of seedlings, as shown in Table 18. In the gobi to the north of Linze, the organic content of the surface layer to a depth of 20 cm is 0.37-0.64 per cent, up to five times as high as on unflooded ground. A six-year-old *Populus cupidata* can stand as high as 5-6 m with a diameter at breast height of 8.55 cm, serving as a defence against sterile gobi lands. At the Nanhu People's Commune, Dunhuang, in the part of the Hexi Corridor, sand dunes levelled with floodwaters have turned barren gobi into stretches of timberland.

Table 18. Advantages of ditch planting for the growth of trees (Pinguan People's Commune, Linze)

Trees planted	Age of seedling (year)	Age of tree (year)	Height of tree (m)		DBH (cm)		Mean diameter of canopy (m x m)
			Average	Max.	Average	Max.	
In ditches	2	5	4.2	5.2	3.6	4.62	1.2 x 1.2
In the open	2	5	2.2	2.15	0.9	1.20	0.6 x 0.6

A review of the examples taken from the experience of the Chinese people in building new oases shows that all the methods adopted – overall planning, water conservation projects, levelling desert lands, establishing tress to provide protection against wind and sand, improvement of soil quality – link together and converge to form a unified process for re-claiming barren lands and developing agriculture. The total area of oases in the Gurbantünggüt Desert, Xinjiang, has increased 6.2 times over pre-liberation days. The total acreage under tillage in the Hotan District on the south-western fringes of the Taklimakan has tripled since liberation.

Monitoring Desertification in China

Deserts in China have expanded due to the advance of wind-driven sand dunes. At the same time, regions that were not true deserts have become desertified. This is due to the work of man, who has disturbed the ecological balance in arid and semi-arid areas. As desertification continues, it becomes progressively more difficult to deal with. Consequently there are great advantages in treating it promptly, as soon as it appears.

Desertification is a discontinuous process. Careful monitoring is required to determine where and when it is occurring. Its strength and development are gauged against a series of selected indicators:

1) *The movement of wind-blown sand.* Wind erosion of exposed soil and the mobilization of dunes provide the main indicator for estimating the strength of desertification. A number of measurements are included within this indicator, such as the proportion of sand dunes per unit area and the velocity of their advance, the depth of wind erosion and the amount of sand accumulating on the surface of the ground. The wind is measured too – its velocity, its sand content near the surface, and the frequency of sand-carrying winds.

2) *Changes in aridity.* Climate measurements must be extended over years to determine, for example, average annual precipitation and its seasonal distribution. In this way, the frequency of drought is established. The aridity index is regularly measured so that trend in aridity and its fluctuations can be monitored.

3) *Vegetation cover.* The proportion of the surface covered and the density of the vegetation are principal indicators of desertification. A reduction in vegetation cover usually indicates an increase in sand dune activity.

4) *Changes in soil.* Factors to be monitored include the soil's physical composition, the proportions of particles of different sizes, its organic content, and such physical properties as weight per volume, porosity and structure. In some situations, attention should be paid to the soil's chemical composition and changes in its salt content.

5) *Changes in water regimes.* These include changes in the moisture content of the soil, in the depth of the water table and in the water's mineralization rate. Changes in the chemical substances dissolved in the water should also be monitored.

It is of the greatest importance that in addition to these natural indicators, the human factor should also be monitored. What needs to be determined is whether the land is being utilized rationally. Observations should determine if utilization is adapted to the resources and natural conditions of arid and semi-arid regions, especially in transition areas between the desert and the steppe. In either cropping or animal husbandry, overutilization will disturb the natural eco-balance and lead to diminished biological production. Therefore great attention must be paid to the carrying capacity of pastures and to the climate conditions in which dry farming is carried out. If rainfed cropping has been overextended or overgrazing is being practised, desertification will appear with the natural indicators listed above.

Because desertification is a patchy process, monitoring must be continuous so that trends can be determined. Changes in desertification indicators will be detected not only by ground surveys but also by the analysis of aerial photographs.

The Development and Utilization of Surface Water Resources in the Construction of New Oases in Desert Regions

In western China, most deserts are to be found in intermontane basins, such as the Taklimakan in the Tarim Basin and the Gurbantüggüt in the Junggar Basin. In the mountain ranges around these basins, rainfall is abundant and the peaks covered with snow and ice. An important step in developing and utilizing land resources in desert areas is to make full use of these water resources. Reclamation in the basin of the Manas River illustrates the techniques developed in China for utilizing surface water to construct new oases in desert areas.

After the Manas River has emerged from Tian Shan, it flows north-westerly across the Junggar Basin through a plain composed of diluvial-alluvial piedmont fan and alluvial and alluvial-lacustrine formations. The whole landform slopes from south-east to north-west to a low point in the centre of the basin that is only 230 m above sea level although it is the heart of the continent of Asia. The piedmont fan is made up mainly of depositions of Quaternary boulders and gravels where seepage is severe and the surface gradient as steep as 5-10 degrees. As ground water reaches the surface, the frontal zone of the fan forms springs and swamps with the latter characterized by relatively serious salinization. Flowing north-west, the river leaves the piedmont to enter an alluvial plain of sand-clay and sandy clay. Here reclamation has been pursued where old oases have made use of the flat relief, relatively high water table and thick vegetation. Further to the north-west, the old lacustrine plain shows a surface covered with aeolian sands of the Quaternary period. Dunes are predominantly longitudinal and of honeycomb form lying on sandy ridges, most of them so covered with vegetation that they have become fixed or semi-fixed.

If land is to be reclaimed and new oases built, an extensive and detailed survey of land and water resources is first of all required. On the basis of such a survey, a programme of water use was developed for the Manas River Basin, its resources harnessed by *diversion* via canals, *delivery* via channels lined to prevent seepage, *storage* in reservoirs, and finally, *irrigation* applied to productive fields. Following this programme, the irrigated area in the river basin has been enlarged 10 times, from about 600,000 *mu* in pre-liberation days to over 6 million *mu* at the present time.

Diversion. To achieve efficient diversion, the main headworks were built in the lower limit of the runoff area, that is, in the piedmont close to where the river leaves the mountains. Additional headworks were built on tributaries, some even in the mountains, so that the maximum amount of water is diverted into the artificial conduit. These structures were built to handle floodwaters with provisions for recollecting the seepage lost through gates and for flushing out the sand carried down from upstream. Additional diversion works were built downstream to make sure that no waters are wasted. The system's efficiency is relatively high, diverting about 70 per cent of all the waters in the basin and up to 85 per cent of the waters in the Manas River itself.

Delivery. All trunk canals carried through the piedmont fan are paved with watertight materials to prevent seepage. Paving usually consists of locally supplied gravels. Channels are lined with pebbles, with cemented pebbles, or with pebbles on the bottom and cement slabs on the slopes.

Storage. The river shows seasonal flow. To alleviate spring droughts, reservoirs of various sizes have been built on the alluvial plains to store floodwaters and winter waters. Reservoirs have been constructed mainly in places characterized by springs or where backflow might occur.

Irrigation. Before the waters were regulated, rivers and streams in the Manas Basin flowed through the twisting, braided channels typical of rivers in flat drylands. By directing the waters into canals, the system achieves a utilization coefficient that delivers more than 60 per cent of the basin's flow to the irrigation points. Needless to say, efficient use of the water requires proper irrigation practices, with the water applied regularly in the proper amount and at the proper time.

With the system in place, measures are then taken to improve the quality of the soil.

Improving Saline Soils

Washing salts from soils

According to studies undertaken, the salt tolerances of the preferred crops in the reclaimed area are as follows: Total soluble salts 0.1-0.4 per cent, chlorides 0.03-0.07 per cent, hydrocarbonates less than 0.04 per cent and carbonates less than 0.007 per cent. The salt content of the soil is usually in excess of these amounts, and to get below these limits, salts must be washed from the rooting zone before planting. During this process and before these limits are reached, salt-tolerant plants can be sown and harvested.

To desalinate the soil to a depth of 80 cm, 400-500 cu. m./*mu* of irrigation water are usually required. Too much water will often result in secondary salinization by raising the water table too high, with consequent loss of nutrients, damage to soil structure and deposition of alkaline salts by evaporation. After the salt has been removed by application of water in the correct amounts, the ground should be covered by plantings of winter wheat or of green-manure crops.

Developing artesian wells

These are used to expand water resources and to prevent salinization. To remove salts and prevent their return the following measures were undertaken. First, in areas of flowing springs where water quality is good and the water table high, pumps were installed to lower the water table and placed in operation either seasonally or all year round. In such settings, effective drainage must be ensured. Second, in areas where the water table was not so high but the water quality was good or could be made good by mixing with canal water, the emphasis was placed on irrigation which, when properly applied, can lower the water table. Third, where the water table was high and the water quality poor with a high admixture of salts, the water had to be desalted before it could be used. Fourth, where the water table was low and the water quality good, artesian wells were opened in the cultivated areas and the water used for local irrigation with excess water being allowed to drain off naturally.

Botanical lowering of the water table

The extensive root systems and strong transpiration of trees planted in shelter belts provide an economical and effective means of lowering water tables. By intercepting water that has seeped from channels, tree roots prevent secondary salinization. For the maximum effectiveness of this "vegetative drainage", attention must be given to the rational arrangement of shelter belts and to the proper choice of trees. If bio-drainage is its main purpose, the shelter belt should be established perpendicularly to groundwater flow so as to intercept runoff. The width of shelter belts and distance between them should be determined by volume of the groundwater flow.

As to species, fast-growing willows and poplars are preferred because of their strong transportation and thirst for groundwater. Planting distances should also be measured by wind penetration and requirements for tree growth. Bio-drainage by shelter belts should be combined with cultivation, drainage and other measures for lowering water tables. If the land is not level, waterlogging may occur in low spots and forest belts alone will not be so effective in preventing secondary salinization.

Irrigation Techniques Determined by Conditions

Irrigated areas on the piedmont fan are located near the headworks and thus have adequate water supplies. The slope, however, is steep and the soil shallow and friable, poor in water-holding capacity and susceptible to erosion. Irrigation efficiency is therefore low. Frequent and shallow irrigation is the technique recommended here.

On the fringe of the piedmont fan, the water table is high due to the movement of groundwater. The slope is comparatively gentle and the soil moderately deep and fertile. Furrow irrigation should be combined with measures for improving the soil and with the installation of good drainage systems. Alternate furrow irrigation is used for crops during the growing season and small-bed irrigation for densely seeded crops. The width of the irrigation bed is one to two times that of the seed lines, with the length determined by the evenness of the land since uniform watering is required. In certain places, artesian wells are used to lower the water table and prevent soil salinization. The total amount of irrigation water required will be 400-500 cu. m./*mu*.

In irrigated areas on the alluvial plain and on the desert margin, river water is still the main irrigation source. Reservoirs are provided to regulate the flow, and artesian wells are located in certain areas. Here the land is flat and the soil is deep and heavy, rich in soluble salts and with a strong ability to hold water. As the desert is approached, sand dunes appear and the configuration becomes undulating. This hinders the use of open drainage systems, so "dry drainage" is preferred, that is the use of micro-relief differences to establish soil and water regions. Salts from irrigated lands are transferred to neighbouring non-irrigated lands. Nearby lowlands are used as a natural evaporation tank.

Hydraulics for Sustained Yields

Thus in reclaiming land on the south-west fringe of the Gurbantünggüt Desert and on the north slope of the Tian Shan, people of several nationalities in the Manas River Basin have constructed hydraulic engineering works and irrigation systems and have carried out irrigation, soil improvement and the control of wind and moving sands. As a result, they have established complex units of a new type. In these new-style oases, hydraulics perform the principal tasks. A balance between water and soil resources is successfully achieved by the regulation and storage of river waters and a rational system of irrigation. Measures to improve the quality of the soil are combined with the control of unfavourable environmental factors. Agricultural production has been stabilized and further desertification prevented.

Stabilizing Sand Dunes with Vegetation

Moving sand dunes are not uncommon in the northern parts of China. They threaten and can cause damage to farmlands and pastures, road and railroads, communications systems and population centres. To avert this threat, sand dunes must be stabilized and fixed in place, and this can be done with appropriate plantings of trees and shrubs. However, natural conditions vary in north China, and plant species must be selected with the particular locality in mind. Otherwise the objective will not be achieved.

The selection of the right species will depend on a thorough understanding of local habitats. Conditions must be known such as prevailing temperatures, wind velocity and direction, thickness of the sand layer, the composition of the underlying material, depth and quantity of groundwater, dunes types and their dynamics, the water regime, the physical and chemical properties of the sand and subsoil.

Selection will also depend on understanding the botanical characteristics of the potential species. This will include knowledge of their natural geographical distribution, their biological and ecological characteristics, and their physiological indices.

In the end there is no substitute for actual tests. Different species must be tested in experimental plantings in different natural conditions. Such experiments have been carried out in China.

Selection of Species in Semi-Arid Regions

Semi-arid regions include steppe grasslands transition zones from steppe to desert. They include much of the Mu Us sandy land, the Hedong sandy land in Ningxia and the south-eastern frontier of the Tengger Desert. They show an aridity index of 2-4 and annual precipitation of 150-450 mm. Fixed and semi-fixed dunes are widely distributed among them although moving dunes are also encountered, especially on the shores of lacustrine basins. The organic content of moving dunes within a depth of 10 cm averages 0.0262 per cent while fixed dunes, in contrast, show 0.629 per cent. All but 7 per cent of the particles in moving dunes are between 0.07 mm and 0.3 mm in diameter. The moisture content of dunes is higher on the windward side, reaching 2.5 per cent, with a little less moisture on the top and the least, 2.24 per cent, on the lee slope.

The vegetation on sandy lands in semi-arid regions consists mainly of shrubs and herbaceous plants of a restricted number of species. The amount of cover is low, reaching a maximum of 50-60 per cent only where water is available near the surface.

The flora is typical Mongolian, represented by such species as *Amygdalus mongolicus, Calligonum mongolicum, Zygophyllum xanthoxylon*. There are relict species in the Alxa Region among which are the evergreen broad-leafed shrubs such as *Ammopiptanthus mongolicus* and the bushy *Gymnocarpus przewalskii. Corispermum petelliforme* and *Stilpnolepsis centiflora* grow rapidly after rain falls on moving dunes. Even as ephemerals they can create stable conditions for *Artemisia sphaerocephala* and *Hedysarum scoparium*. As the seedlings of these pioneers expand their shoots after being buried in sand, they tend to fix the dunes to some extent.

Under the protection of *Artemisia sphaerocephala* it is possible for *Artemisia ordosica* to grow and form communities. The *ordosica* species possesses a much greater ability to stabilize dunes than the *sphaerocephala,* and under the protection of the former, perennial herbs such as *Allium mongolicum, Kengia mutica* (*Cleistogenes mutica*) gradually invade the area and expand the vegetation cover. This of course increases the consumption of water in the upper layers of the sandy soils. As the moisture becomes deficient at a depth of 1-1.5 m below the surface, *Artemesia ordosica* will begin to wither.

Sometimes, before the moisture around the intertwining root system of *Artemisia ordosica* is exhausted, seeds of *Caragana korshinskii* may germinate and grow during the season when the soil is moist. Their roots may then penetrate quickly through the dense distributions of *Artemisia* roots to penetrate deeper below the surface.

This establishes a situation in which subsequent competitors can appear. *Ceratoides latens* sends its roots deeper than 1.5 m, and *Ceratoides* communities may replace *Caragana*. When this happens, the surface becomes harder and erosion is halted even though the cover may not generally exceed 40 per cent.

Finally, *Ceratoides* will be replaced by communities of *Reaumuria soongorica + Salsola passerina*. With these communities, the ground surface will be fixed even though the cover is still less since the plants are dwarf varieties and their growth is very slow. These traits make them unsuitable for selection as sand-fixing plants even though they are drought resistant.

A typical natural succession might then proceed as follows: *Agriophyllum squarrosum + Corispermum patelliforme – Artemisia sphaerocephala + Hedysarum scoparium + Artemisia ordosica communities – Caragana korshinskii – Ceratoides latens – Reaumuria soongorica + Salsola passerina communities*. A natural succession of this type shows that:

1) There is great variation in annual rainfall with plants germinating best in moist years. Growth is inhibited by strong winds and moving sands. Therefore the succession will proceed very slowly.

2) In this sequence of psammophytes, only shrubs, undershrubs and herbaceous plants survive because of the limitations of water. Even survivors cannot achieve great density, and a cover of 60 per cent is considered to be the maximum.

3) The fast-growing pioneers utilize whatever water there is in the sand. Thus as the dunes begin to be fixed, their moisture tends towards exhaustion and becomes unfavourable to plant growth. In such circumstances, plants that are more drought resistant and long-lived should be substituted. In the controlled fixing of dunes, pioneers and successional plants are used in combination.

In an analysis of sand-fixing plants carried out at the Shabodou experimental station, the following conclusions were reached:

1) It is important to study the root system of sand-fixing plants. For example, the root systems of many pioneer plants grow horizontal on moving dunes while successional plants are characterized by deep root systems. Plants with purely horizontal root systems provide small cover and cannot fix sand. Plants with vertical root systems easily suffer from wind erosion. Thus, on selecting species, combinations with different root systems should be considered so that the sand can be fixed while moisture at different layers is utilized. In natural communities, *Haloxylon ammodendron* + *Nitraria tangutorum* and *Caragana korshinskii* + *Artemisia ordosica* are examples of good combinations. Different species, of course, must be able to tolerate common ecological conditions.

2) Tests determine which trees are best for wind protection. *Eleagnus angustifolia* is indigenous to riverbanks in arid regions of China. It is adapted to a moist atmosphere but lacks resistance to drought. This species is undergoing further tests.

3) Indigenous plants are effective for stabilizing sand dunes. Among the species shown to work well are *Hedysarum scoparium, Caragana korshinskii, Artemisia ordosica* and *Artemisia sphaerocephala.*

4) Plants indigenous to dunes in central Asia are resistant to drought and wind erosion. *Calligonum caputmedusae* and *C. arborescens* are large plants with well-developed root systems. They can be introduced and cultivated.

Selection of Species in Arid Regions

Arid and desert regions of north China cover huge areas. They include the Urad Middle and Rear Joint Banner along the Yellow River to the south of Helan Mountain, the Ulan Buh and Badin Jaran deserts, the Hexi Corridor, and the immense Tarim, Junggar and Qaidam basins. These are temperate regions with cold winters where the aridity index can easily exceed 80. They are characterized by annual precipitation of less than 150 mm, in some places not exceeding 10 mm. Moving sand dunes are typical of these regions, everywhere except in the Jungger Basin, where the dunes are semi-fixed.

In the spring, *Agriophyllum squarrosum* and *Horanninowa ulicina* can be seen scattered over moving dunes. Sometimes tufts of *Aristida pennata* appear on flat sand. *Ephedra, Artemisia* and *Calligonum* spp. grow interspersed on semi-fixed dunes. *Haloxylon perscicum* inhabits the dune top while *Haloxylon ammodendron* is dominant on the lower slopes and in saline depressions between dunes. *Tamarix* and *Nitraria* spp. tend to fix dunes into an undulating surface. Tamarix germinating on the tops of the dunes will soon use up the available moisture and, unable to tap groundwater, will wither and die. Nevertheless, if the tamarix is cut down, the wind will get at the sand again and mobilize the dune, setting it once more into motion.

When *Haloxylon ammodendron, Tamarix* and *Nitraria* tap groundwater, they tend to flourish with great benefit to the soil. This sort of growth should be encouraged.

Experiments conducted in test plots have led to a number of conclusions:

- Plants introduced into arid regions must be drought resistant. One such species is *Haloxylon persicum*.

- Salinity is common in arid regions. Salt-resistant plants as *Tamarix hispida* must sometimes be selected.

- Where groundwater is available, plants capable of utilizing it should be considered. These include *Haloxylon ammodendron* and *Populus euphraticus*.

- Where irrigation from the groundwater is possible, the plant species may be broadened appropriately. *Salix mongolica* and *Atraphaxis bracteata* are among the species that should be considered.

Conditions in true deserts are of course more severe, and climate often sets a limit to what is possible. Vegetative methods are sure to fix moving dunes if irrigation is available and plants can be established in a checker-board pattern.

The Establishment of Forest Shelter Belts in Oases: Principles and Technology

China's interior west of the Wushao Ling section of the Helan Mountains and north of the Tibet-Qinghai plateaux consists largely of temperate zone deserts and drylands. While the region contains mountainous terrain, much of it is made up of sand dunes, gobi and saline soils. In much of it, too, the climate is arid, with annual precipitation below 200 mm.

Oases are located on gobi lands or on the desert fringe, often drawing water from the melting of snow in the surrounding mountains. Such places wage a constant battle against drought, salinization and drifting sand. If agricultural production is to be sustained and improved in this region, measures must be taken to prevent the desertification of oases and to expand their productive areas.

The life of an oasis is based on its irrigation system. Research and experience indicate, however, that in addition to the rational development of irrigation, belts of productive forest should be established as an effective means of blocking wind and sand. Such shelter belts maintain the oasis eco-system while becoming an essential element in that eco-system. This can be illustrated by oases in the Xinjiang deserts.

Shelter Belts for Maintaining A Balance in The Oasis Eco-system

A system of shelter belts include large areas of sand-fixing grasses and shrubs combined with trees that mark the rim of the oasis plus interior networks or grids of trees that protect the separate fields. Such shelter belts participate in the energy transformations and circulation of substances that constitute the oasis eco-system.

As an essential part of the oasis structure, a protective network of shelter belts has effects that extend through the entire system. Among their organix functions, shelter belts transform energy to create additional biomass that would otherwise not be used. It is a biomass that is effective in countering harmful energy, as represented by strong winds and high temperatures. It helps to regulate the local microclimate by transpiration that consumes and exhales moisture. Belts of trees accelerate the circulation of salts in the soil and replenish organic content.

Shelter belts as wind-breaks

In considering the efffect of trees on wind velocity, more than the total wind-speed reduction must be taken into account. Some circulation of air is desirable within the limits of what is safe for plants. The optimum wind velocity should be estimated. The range of protection provided by trees –

their downwind effect – must enter the calculations. The goal is to develop forest belts that have optimum structure.

Characteristic of velocity fields behind close-structured forest belts are two closed eddy currents, one small and the other large, with a vertical range of about 0.6 *H* (*H* = tree height) and a horizontal range of 8-10 *H*. Discontinuities appear in the air flow in front of the belt and behind it.

The windward air is forced upward to be lifted over the trees. As it flows over the treetops, the air speeds up, with a pronounced Venturi effect at close to 2.5 *H*. A tight velocity gradient develops between the accelerated air and the eddy currents beneath within the momentum transferred downward strongly. Thus, with dense shelter belts, the leeward wind speed is restored rapidly, limiting the protective range to about 15 times the tree height. Within the range, wind speed will be reduced by an average of 39 per cent.

Loosely structured belts show a different pattern of air speed. As the air reaches the belt, part of it penetrates to form a low velocity zone near the ground surface to the lee of the trees. It forms an eddy whose curve lies between 4 *H* and 13 *H* to a height of 0.2 *H*. The other part of the oncoming wind is lifted over the belt where it speeds up due to the Venturi effect. The velocity gradient, however, is weaker than with a belt of close-set structure, as in general, the velocity gradient declines with increasing porosity of the shelter belt. Up to a point, the range of protection increases with a looser structure, reaching 23 *H* with wind speed reductions of 40 per cent within the protected zone.

As is characteristic downwind of well ventilated shelter belts, the air stream separates into three components. The first is directly over the belt, with the air accelerated in inverse proportion to the belt's porosity. A second acceleration zone forms on the leeward side exactly where the tree trunks rise from the ground, but this is quickly weakened by friction with the surface. Beyond this is the low velocity zone, which extends out to where open-field conditions are gradually re-established. This pattern of air movement extends the zone of protection created by the belt.

Forest belts of ventilating structure can be classified as easily permeated or poorly permeated depending on the species composition, the coefficient of penetration and the height of the trunks of mature trees. In easily permeated belts, trunks heights will run around 3 m and canopies of foliage are separated. The penetration coefficient will measure about 0.7 and the range of protection will be 11 *H* downwind. Poorly permeated canopies link up with each other, permitting only moderate ventilation. Here, with a trunk height of 2 m, the penetration coefficient will be 0.5, and the protected area will extend from 24 *H* to 38 *H* in a zone in which wind speed is reduced by 34-48 per cent. Belts of well-spaced trees permitting passage close to the ground but with poorly permeated growth above are widely used to protect farms in Xinjiang.

Changes in wind velocity have an influence on the protective capacity of shelter belts. A loosely structured shelter belt will reduce wind speed by 25 per cent when the wind is blowing at grade 3 on the Beaufort scale, but will reduce a grade 7 wind by 40 per cent over a longer range. If the belt permits ventilation, the speed of the air passing directly through it will increase as the wind speed rises, and the protective effect is not enhanced. A shelter belt of that type works best at moderate wind speeds. If drifting sand is a severe threat, a less ventilating structure is to be preferred, but not if the sand is blown in the wind.

The protective effect of a shelter belt is directly proportional to the height of the trees. For example, trees 8 m tall will reduce wind speed 54.7 per cent more than will trees that are 6 m tall within 20 *H*, while trees 10 m tall will have an effect 95.6 per cent greater than the 6 m trees.

The angle that the prevailing wind strikes the belt makes a difference in the protective effect. In moderate wind conditions, a loosely structured belt perpendicular to the wind will reduce wind speed by an average of 39.1 cent within a range of 30 *H*. When the wind strikes the same belt at an angle 45°, the average reduction in wind speed is 43.5 per cent. The reason for this is that the angle of attack causes a change in the coefficient of penetration.

The geographic setting and specific conditions must be kept in mind while designing a shelter belt for structure and permeability. Both these qualities will change as the stand of trees matures. To maintain the shelter belt's protective effects at an optimum, control and management must be applied to the stands of trees at all stages of their development.

A system for protecting fields widely adopted in Xinjiang consists of narrow belts established in tight grids. A close spacing of belts within the oasis creates a pattern with an overall dynamic effect, with each belt presenting only a moderate wind to the next. In adaptation to desert conditions, each belt offers protection to its neighbour, enabling the trees in each successive belt to grow normally and take their place in a stable network.

Even with a narrow belt consisting only of 4-6 rows of trees with low permeability, the wind-breaking effects can be remarkable, averaging 41 per cent over 20 *H* in south Xinjiang. The narrow belt must keep a density sufficient to maintain its profile. While the main species are maintained in place, ancillary species with heavier crowns are arranged around them forming a multilayer canopy typifying a well-structured shelter belt. Narrow belts closely spaced reduce average wind speed inside the oasis 20.2 per cent more than if the grids are widely spaced.

Shelter belts as defences against sand

In oases confronting wind-blown or drifting sand, belts of shrubs and grasses are established on the perimeter facing the wind outside the outermost shelter belt of trees. These rings of low vegetation are wide, 200 to 500 m, and planted directly in the sand to increase surface roughness. A layer of air forms over the vegetation, decreasing the kinetic energy of the wind at the surface. The amount of friction offered to the wind is proportional to the height and denisity of the grass and shrubbery. Observations indicate that such belts offer 17 to 27 times the resistance of naked sand. Thus, sand-bearing winds are already weakened when they enter the forest belts.

In shelter belts in which the trees are well spaced, air passes readily through the lower part. The grid presented to the wind by the trunks of the trees creates a Venturi effect, and the surface current will speed up within the belt. This can cause wind erosion of the surface on which the trees are planted if the forest belt is unprotected by an outer buffer of grasses and shrubs. Surface sand is picked up within unprotected forest belts and deposited 5 *H* to 7 *H* behind the trees.

If the shelter belt has a structure of trees tightly spaced, and if it is exposed directly to sand-bearing winds, aeolian deposits are dropped in front of the belt and inside it. Dunes are formed, growing ever larger, and the trees will eventually be buried.

The best defence against blowing and drifting sand is provided by a belt of six to eight rows of trees at the perimeter, structured to provide surface ventilation, and itself protected by a wide outer belt of shrubs and grasses. By the time the wind strikes the trees, much of its sand content will already have been winnowed out by the buffer of shrubs and grasses. Very little sand will be deposited within the belt of trees or within a range of 3 *H* downwind. The composite system as described provides a basic solution to the problem of sand at the windward rim of the oasis.

Microclimatic effects of shelter belts

Farmland under the protection of shelter belts has less wind at the surface with a weakening in turbulent exchanges. There is a drop in the rates of exchange of heat and moisture in air and soil and better regulation of water consumption by growing plants. By helping to keep the water table low, shelter belts act against soil salinization. Trees help mitigate the impact of climatic extremes, helping croplands to survive seasons of drought.

Under the protection of a shelter belt, as studies have shown, surface temperatures are raised by 0.7-3.5°C in the cool spring, while subsoil temperatures at a depth of 5-20 cm are higher by 0.4-1.0°C. In the hot summer, the air temperature at a height of 1 m can be reduced by 0.1-2.0°C, while the relative humidity is increased by 3-14 per cent. In winter, the surface temperature under a cover of snow can be 0.2- 0.6° C higher.

When the hot drought wind blows in the Turpan region, within three hours a sustained temperature reduction of 0.9-2.0° C is achieved in a range of 1-10 *H* behind a shelter belt with a well-spaced structure. After the wind dies down, the relative humidity within a range of 1-10 *H* rises by 39-50 per cent in comparison with that above unprotected ground.

The presence of a shelter belt directly affects the water circulation in protected plants. In wheat, for example, the suction pressure is reduced -- to 9.5 atmospheres in the lee of a shelter belt in comparison with 13.7 atmospheres outside a range of 10 *H*. Water consumption is regulated, ineffective consumption reduced, and the chances are increased that crops will survive drought without damage.

Still other microclimatic effects are produced by shelter belts in desert regions. Since irrigation canals and ditches are shaded by the belts, surface water evaporation can be reduced by 40 per cent. Because the trees act to conserve water, the humidity of the soil within the belt and in nearby cropland may be raised by 10-13 per cent in the dry spring. Within a range of 4-12 *H* behind the belt, the transpiration of cotton is reduced by 38 per cent. When summer comes, the soil humidity down to 100 cm can be raised by 8-9 per cent.

Because of its own demands for water, a shelter belt tends to keep the water table low. For a range of 75-100 m on both sides of a mixed belt composed primarily of *Populus nigra* var. *thevestina* and *Salix alba,* the water table was found to have been lowered by 0.2-0.7 m. This helps to keep salts from accumulating on the surface.

Techniques of Constructing Protective Shelter Belts

Structuring a composite system

Where sand is a serious threat, the protective network should include a wide belt of grass and shrubs beyond the perimeter shelter belt on the windward rim of the oasis. Within the oasis, the network will be constructed according to the principle of "narrow belts in tight grids"

In constructing the outer shrub-grass belt, dunes and eroded areas can be surrounded by plantings to protect whatever vegetation they already contain. Irrigation will be provided by winter or summer floods to establish a belt that is 200-500 m in width. Plants should be selected that are resistant to drought and erosion and are capable of stabilizing moving sand. These criteria permit a fairly wide range of choice, with selection carefully adapted to local conditions.

Experience shows that preferred grasses are *Alhagi sparsifolia, Glycyrrhiza uralensis, Karelinia caspica, Soorzonera divaricata, Phragmites communis* and *Achnatherum splendens.* Shrubs that work well include *Capparis spinosa, Calligonum* spp., *Tamarix* spp., and *Nitraria sibirica.* These can create a vegetation cover of more than 60 per cent with a surface roughness within the belt 30-40 times that of exposed sand. The surface air flow becomes turbulent inside and beyond the belt of vegetation, lessening the momentum of wind-driven sand. As a result, wind erosion is abated. These effects are evident early in the development of a shrub-grass barrier, as the vegetation begins to stabilize the shifting sand.

Besides the protection it offers, a belt of grasses and shrubs provides carefully controlled grazing and can be cut as fodder. Depending on what species are planted, herbs with medical value can be gathered as well as the materials for producing charcoal.

Protection against sand on ridges and high ground

Shelter belts on high ground are composed of tall trees intermixed with shorter varieties, planted well spaced so that light penetrates evenly from top to bottom. Each belt consists of six to eight rows of trees with a spacing between belts of 50 to 100 m. Where sand is a particular threat, the trees are bordered by belts of shrubs and grasses. Perennial grasses and sand-tolerant crops can be planted in the open space between belts.

Drought-resistant trees that provide good wind protection are desirable for shelter belts established on high ground. These include *Eleagnus oxycapa, E. moorcroftia* and *Ulmus pumila.* Where sand is a severe problem, shrubs such as *Tamarix* spp. and *Hippophae rhammoides* should be planted on the windward side of the trees. Where the surface consists of undulating dunes, techniques such as "block in front and pull from behind" should be applied to level the land.

Narrow belts in tight grids

This is the most widely used system for protecting the fields inside the oases of the Xinjiang deserts. These central sections of shelter belts play a major part in regulating the oasis microclimate and in maintaining a stable eco-system.

Internal shelter belts are accompanied by roads and irrigation ditches. They are usually constructed of well-spaced structures with good surface ventilation. They are narrow, consisting of four to eight rows of trees. The distance between belts is usually 250-300 m, but in extremely dry situations with a serious sand problem, the distance between belts is made even tighter, typically 120-200 m.

State farms, communes and brigades in newly reclaimed areas work to expand their productive farmlands be extending their forest belts and transforming the desert. Communes inside oases work to improve their fields a parcel at a time while designing and establishing a system of shelter belts.

Plans for afforestation must be closely co-ordinated with capital construction in the fields and must include attention to more than merely trees. Ditches and roads must also be laid out and fields formed in convenient shapes and sizes. A typical field in a tight grid system will be 13 hectares in size. Designs should strive to reduce the areas occupied by shelter belts to the minimum, so that water used and other costs will be reduced while maximizing the land available for crops.

Poplars are the species most commonly used in internal shelter belts. Whatever species are selected, they must be drought resistant and long-lived while offering an intrinsic economic value. Belts call for a mixture of species, with the trees planted in furrows or ditches. Selection also calls for careful attention to local conditions and for species that are well adapted to such conditions.

Evaluating Protective Effects

The effects of a shelter belt on the microdynamics of the atmosphere are what enable it to provide protection. To calculate the protection that a line of trees should provide, the following formula is employed:

$$P = K\,(HM/D)\,100,$$

in which P is protection in per cent, H the average height of the trees, M the range of protection downwind, D the distance between belts, and K a constant representing the inverse of the permeability. A closely spaced structure with no ventilation will be $K = 1$, while no belt at all will be $K = 0$. A well-spaced structure providing good ventilation will be $K = 0.7$.

Northern Xinjiang on the slope of the Tian Shan is characterized by strong sand-bearing winds and an aridity index of 4-10. Open grids in this region marking off fields as large as 50 hectares provide 50-60 per cent protection, and the protection is higher for smaller fields, which means shelter belts more closely spaced. Experience indicates an optimum field size at 13-20 hectares, surrounded by narrow belts of 4-6 rows deep, separated by 250-300 m distance between belts.

In southern Xinjiang, aridity rises to an index of 20-60. On the average, the wind blows at Beaufort 6 or higher for 31 days in the year with sandstorms on 14-35 days in the year. Salinization and alkalization are added to problems that create severe conditions in which to carry out agricultural production. Here, shelter belts are 4-8 rows deep and spaced 250-300 m apart, creating fields of 15 hectares. The distance between belts should be reduced to 150-250 m.

In Turpan below a wind gap through the Tian Shan and in other places in both northern and southern Xinjiang, aridity rises to 70 and the wind blows at Beaufort 8 or higher for 21-42 days in the year. The conditions can be destructive to agriculture. Networks creating fields of 15 hectares show protective efficiencies of 67 per cent after the trees have matured. This suggests that belts of 6-10 rows of trees should be spaced more closely together, creating fields no larger than 10-13 hectares. Yet even with its present system of shelter belts that are spaced widely, Turpan is expanding the area it maintains under cultivation.

The Utilization and Improvement of Pasture in China's Steppe Zone, Taking the Ordos Plateau as an Example

China's semi-arid steppe regions are mainly located in the central and north-eastern parts of the Inner Mongolian Plateau between 35° and 50° north latitude and 105° and 120° longitude. They cover 8.6 per cent of the total area of the country. They include such areas as the Ordos Plateau, Xilin Gol, Hulun Buir and the Horgin, Orzindag and Mu Us sandy lands. The steppes are undulating plains at 1,000-2,000 m above sea level with sandy lands interspersed among them that consist mainly of fixed and semi-fixed dunes, although shifting sands occur in patches among them, especially on lake basin lowlands.

The mean annual temperature is 5-7° C in the semi-arid steppe regions. It is somewhat lower in the north-east, as in Manzholi and Xilin Hot, where the average is 1.4° C and is warmer in the south-west, as at Lanzhou, which enjoys an annual average of 8.1 to 9.1° C. Half the year is frost free. Annual precipitation averages between 250 mm and 400 mm with the rainfall occurring in a markedly seasonal pattern. As most of the rain arrives with the south-east monsoon, 60-70 per cent of the precipitation is concentrated in the period from July to September in the form of heavy downpours. The 20-30 per cent of the annual rain that falls in the months of April through June is usually too thin to be of much use. According to statistics collected over the years, it seems almost a rule that a severe drought occurs once in six years, followed by two years of good rain with a lighter drought in the third year. The aridity index for the region is between 1.5 and 2.5.

Groundwater is sustained almost entirely by rainfall. The depth of the water table depends on topographic factors, varying from 10 m or more in higher ridges to 1-2 m in lowlands. The water is of good quality, with a mineralization rate of 1 gram per litre.

The soils of the steppes are mainly chestnut mollisols deposited by water and wind. Dark castanozems occur in the east with lighter types in the west. Lowlands contain bogs and meadow soils, with light meadow castanozems.

The Ordos pasturelands are situated in an arid and semi-arid transition zone in the western part of the steppes. The flora of the region is characterized by marked variety because of varied conditions with their distinctive water and energy budgets, topographical features and human activities. According to incomplete information, the Ordos contains 495 species of plants, among which Compositae, Gramineae, Leguminosae and Chenopodiaceae predominate. The commonest vegetation is composed of perennial herbs. Pastures, on the other hand, are characterized by fodder types, mostly xerophytic dwarf shrubs and undershrubs. Because of the prevalence of sandy lands in the Ordos, the vegetation is psammophytic, featuring undershrubs such as *Artemisia ordosica* and shrubs like *Caragana microphylla* and *C. intermedia.* The natural pastures in the Ordos region have the following characteristics:

> They are basically suitable as grazing lands but offer little in the way of grasses suitable for mowing.

- Most of the pastures are better suited to the needs of goats and sheep than of horses and cattle.

- The productivity of the pastures is highly seasonal in both quantity and quality. The highest yields occur in the autumn when pastures offer three to four times as much fodder as in spring. As a result, livestock experiences an annual physical cycle, becoming "strong in summer, fat in autumn, thin and feeble in the spring". This cycle varies greatly from year to year, with animals in their worst condition in drought years.

- Pasture soils are for the most part sand and sandy loam, with sand particles constituting 80-90 per cent of surface horizons.

- In the west and north, the pastures are on higher ground. In the eastern part of the Ordos, pastures are also on lowlands interspersed with moving dunes. In the south, pastures are mainly on lowlands composed primarily of fixed and semi-fixed dunes.

The Protection and Improvement of Natural Pastures

Controlled grazing

The Ordos region has a history of over a hundred years of sedentary grazing. Instead of the former nomadic styles, pens for livestock, wells and pastoralists' settlements are established in certain fixed places. Today, two fundamentally different grazing systems are encountered: uncontrolled free grazing and controlled rotational grazing.

Uncontrolled free grazing around the settled areas with little attempt to direct the movement of animals is characteristic of practices that are now being discarded. Such practices in the past have resulted in the degradation of pastures that are trampled and grazed all year round.

Controlled grazing, on the other hand, produces even pressure on the pastures surrounding the flock point. It is considered a reliable way of avoiding or reducing desertification.

Contrasting examples can be taken from the Otog Banner to illustrate the consequences of the two grazing systems. Both involve flocks of goats in similar environments, grazing on sandy lands fixed by *Artemisia ordosica.*

Flock A has been in existence for only 16 years, during which time it has grazed freely. As a result, the surrounding pastures are severely degraded, with the vegetation cover thinning and the variety of plant species sharply reduced. Certain plants, such as *Cynanchum komarovii* and *Agriophyllum squarrosum,* are an index of degradation, indicated by their increasing dominance. Here, 87 hectares of pasture have turned into shifting sands.

Block B has been established for over 80 years, lasting through three generations of pastoralists. Yet the pastures surrounding the settlement point are undergrazed. They show good vegetation cover abounding in a variety of species.

The herdsmen of this family conserve the surrounding pastures by taking different directions each day, both in going out and coming back. Thus, the grazing is alternated around the central point. Watering is also done in a controlled way. Goats are never permitted free access to the well, so that no pressure is placed on the pasture around the well.

Pasture rights and plot rotation

Only a few years ago, the pastures were not mapped and the right to use them was not assigned. People competing for their use were not motivated to manage them properly or to improve them. In recent years, however, the work of mapping the pastures has been done and rights to them assigned.

In the Shudiban and Jiujeng districts of Jingbian County, Shaanxi, for example, each pastoralist unit began to work out plans for mapping their pastures as soon as the right to use them had been confirmed. They all agreed on a system of rotational grazing within the area assigned to them, dividing their pastures into three or four sections to be grazed at predetermined times. Within one or two years after the inauguration of the rotational system, as surveys indicated, vegetation had increased as much as 4.4-4.7 times and flowering and fruiting plants denser by 3.2-3.3 times. These are ranges, with the sheep showing increased body weight and higher wool yield under rotational grazing, not only because of the improved pasture but also because they do not have to walk so far to get it.

A precise system of rotational grazing has been developed on narrow pastures confined to lowlands. These pastures are divided into a number of small sections. In the morning, the sheep are brought to graze in a plot that has already been grazed twice. At noon, they are transferred to a plot that has been grazed only once before. And in the afternoon, they are moved to an ungrazed plot. This process continues until all plots designated for grazing have been grazed three times. Under this system, sheep show a 3 per cent increase in body weight and an 18.5 per cent increase in wool yield. At the same time, 40-50 per cent of the pasture is kept free of grazing to allow its vegetation to recover from being grazed three times.

Enclose and care programme

On lowland pastures, the government has advocated an "enclose and care programme" as a fundamental means of halting degradation and improving fodder yields. The programme can be applied with relative ease to the lowlands where soil and water conditions are favourable, and extended widely. It has shown remarkable results. The pastures in Otog and Uxin banners, for instance, have shown marked improvement following enclosure. Vegetation has increased in cover and height, with palatable grasses showing the highest increase.

Enclosures have also resulted in considerable improvement to the soil. The amount of litter is higher, protecting the surface against soil erosion. Texture has become finer and the nutrient content has increased.

The programme has subsequently been extended to pastures on sandy lands and higher ground. These pastures, with less access to groundwater are drier and more vulnerable to wind erosion. Experience shows that even under these more unfavourable conditions, enclosures produce excellent results.

Enclosures are not intended to prevent grazing for any extended period of time. What is intended is to prevent grazing during the growing season. In the autumn, enclosed fields can be mowed when they are dense with such fine grasses as *Leymus secalinus* and *Calamagrostis pseudophragmites.* The mown fields then offer their stubble for grazing in winter and spring. Pastures not suitable for hay harvesting are "rested" during the growing season to permit the generation and accumulation of nutrients and spring grazing. Thus in addition to rehabilitating pasture eco-systems and maintaining them in equilibrium, enclosures contribute to a programme of balanced feeding throughout the year.

Reseeding and planting

The pastoralists of the Ordos have acquired a good deal of experience in reseeding grasses and planting fodder shrubs to raise the productivity of degraded pastures, to the great benefit of stock farming in the region. The selection of species for sowing and planting is determined by local conditions.

Lowland pasture covered with sand can be greatly improved by reseeding with legumes. The favoured selection is sweet clover in white and yellow varieties. In the Uxin area, clovers are planted together with *Salix mongolica* to improve the soil between dunes.

Reseeding can improve the productivity of a pasture by 3-7 times. In depressions between the dunes that have been reseeded, hay yield has reached the equivalent of 9,487 kg per hectare. The people of Uxin have combined plantings of sweet clover with weeding out the poisonous *Oxytropis glabra* that infests the region. The growth of clover helps to reduce the presence of this harmful plant.

On semi-arid higher ground composed of fixed and semi-fixed dunes where the water table is low, *Caragana* spp. provide the principal fodder shrubs used to improve the pastures. A similarity of morphological and bio-ecological characteristics prevails among the three species most commonly planted – *C. microphylla, C. intermedia* and *C. Korshinskii*. What makes this genus so useful is:

- *Resistance to heat and cold*. Studies have shown that *C. microphylla* is undamaged by exposure to temperatures ranging from –39° C to +55° C..

- *Resistance to other extreme conditions. Caragana* spp. are universally recognized as among the most drought-resistant plants in the region. The genus is also resistant to wind erosion, sand burial and attack by hailstorms. The drought tolerance of *Caragana korshinskii* has been established by studies of its physiological indices – content of bound water, ratio of bound to free water, water suction pressure and water-holding potential. These studies show it to be superior to such drought-resistant plants as *Oxytropis aciphylla, Artemisia ordosica, Artemisia sphaerocephala, Hedysarum scoparium,* and much superior to mesophytes.

- *Long growing period*. From budding to defoliation, the growing period of *Caragana* lasts for 200 days in the year. Although in winter the vegetation of the pasture turns yellow and withered, *Caragana* remains green.

- *High nutritive value. Caragana* is attractive to stock. Goats, camels, sheep and cattle are all fond of eating its flowers, leaves and green branches. Its pod wastes make excellent feed for sheep. The pastoralists of the Ordos have a good opinion of *Caragana* and consider it a nourishing plant. Analysis reveals it to be rich in protein, minerals and carotene, as shown in table 19.

Table 19. Nutrient composition of *Caragana microphylla*

	Phenophase	
	Growing (%)	**Fruiting (%)**
Moisture	14.95	12.26
Crude protein	22.48	16.84
Ether extract	4.98	3.22
Crude fibre	27.85	35.25
Nitrogen-free extract	22.36	26.50
Crude ash	7.38	5.93
Calcium	2.16	2.99
Phosphorous	0.52	28.70
	(ppm)	
Carotene	28.70	23.50

- *Adaptability*. *Caragana* thrives in a wide range of ecological conditions. It grows in all the Ordos environments except on the larger moving dunes and in lowlands where the water table is high and saline-alkaline conditions prevail. It is found everywhere on higher ground, on sandy or loess ridges and in sandy lands composed of fixed dunes.

- *Long life*. *Caragana* survives for 40-75 years.

- *Easy to work with*. *Caragana* produces seeds. The yield of seed depends on pasture management and the density of the plants and ranges from 20-30 kg to hundreds of kilograms per hectare. Under good conditions, *Caragana* has yielded 562.5 kg per hectare. The plant survives and grows very well whether sown as seed or planted as seedlings.

Because of its favourable characteristics, *Caragana* has been extensively reseeded and planted on higher ground, loess ridges, semi-fixed sandy lands and on dunes that still show mobility. It has become an important weapon for improving pastures and stabilizing sand.

Before 1956, for instance, the Xiejiagou Production Brigade in Jia County, Shaanxi, was so short of pasture that it could run only 95 head of sheep. Between 1956 and 1974, the Brigade planted *Caragana microphylla* on 413 hectares. By the latter year, it was running 1,600 head of sheep. In all of Jia County, *Caragana* has been planted on 5,133 hectares. This has been of great significance in conserving water and soil, stabilizing sand and improving conditions for livestock.

Renewal Pruning of Fodder Shrubs

Certain shrubs and undershrubs, such as *Caragana* spp., *Salix* spp. and *Artemisia ordosica*, have a great bearing on the feed balance for livestock farming. Yet when they reach a certain age, these shrubs tend to become exhausted, begin to droop and loose their vigour both for propagation and productivity, and are increasingly subject to attack by diseases and insects. Experience has shown that these plants can be renewed by pruning. If they are pruned close to the ground surface, their vigour will be restored and they will yield a new round of productivity. Studies have shown that pruning increases the yield of *Salix mongolica* by 132 per cent, of *Salix microstachya* by 127 per cent, of *Caragana intermedia* by 150 per cent, of *Artemisia ordosica* by 103 per cent and *Hedysarum mongolicum* by 33 per cent.

The Control of Moving Sands for Pasture Protection and Expansion

Shifting sands are widely distributed in the Ordos, forming 30 per cent of its total area. Moving sands are a constant menace to pastures and can even bury them entirely. To protect pastures and develop stock farming, great efforts have been undertaken both to combat sand movement and convert dune-lands into useful pasture. These are considered to be two of the fundamental tasks of the region.

Most of the moving sands are situated in semi-arid zones. Here, favourable water and energy conditions offer a good chance of combating sand movement by vegetative means.

Controlling dunes on their windward slopes

Crescent sand dunes are found scattered sparsely among the region's lowlands. They are usually low, no more than 7 m in height, each occupying an area of 1,000 to 7,000 square metres. They are a phenomenon indicative of an early stage in the formation of extensive moving sands. Crescent dunes can send them marching at a rate of over 8 m a year. As they advance, they bury the pasture in front of them. The soil left behind in the wake of these dunes takes at least three years to respond to rehabilitation. Indeed, these dunes cause immense damage to pastures and must be listed as a top priority in programmes to combat sand.

Another severe problem is presented by chains that advance at a rate of 4-6 m per year. The "blocking in front" method is usually adopted to level barchan dunes, that is, to plant *Artemisia* *ordosica* or *Salix mongolica* on the lower third of the dunes' windward face and let the wind blow the top away. As vegetation develops, the wind is prevented from blowing sand off the windward slope, and its velocity is decreased there. *Artemisia ordosica* can reduce wind speed by 60 per cent when it is blowing at 3.7-6.4 m per second, and decrease by 85 per cent its ability to pick up sand from the windward slope. A Venturi effect over the top of the dune will speed the movement of air and help blow the top away. Within a year, a wind-eroded level 6-8 m in width appears in the dune above plants, or at a place one-third of the way up from the bottom. *Artemisia ordosica* or *Salix mongolica* are established in these eroded levels. The process continues for several years until, after several successions of plantings, the dunes are fixed in a pattern of shallow undulations.

Changes also take place in the soil on the stabilized windward slope. Five years after first plantings, the windward surface has acquired a fragile, cloddy structure. The soil has dropped in weight and increased in porosity with an increase in dry soil aggregates. It has also increased its content of nutrients. The vegetation cover on originally naked dunes has reached 28-50 per cent with a dry-matter production of 225-615 kg per hectare.

V-shaped plantings are generally used to establish *Artemisia ordosica*. *Salix mongolica* is planted in bow-shaped layerings or in "erosion preventing squares". All such methods establish the plants in groups. Isolation of plants must be avoided, for single plants are not resistant to wind erosion.

Two other forage plants are effective for fixing sands: *Hedysarum scoparium* and *H. mongolicum*. They can be sown on shifting dunes, saving the trouble of planting, and they eventually create good stands of hay. They are resistant to wind erosion and burial by sand, are fast growing and generate vigourously. They are also high in proteins, minerals and carotene. If they are free of grazing, fields of *Hedysarum mongolicum* will yield 1500 kg of good hay per hectare.

Controlling depressions behind leeward slopes

The low area behind the leeward slope of a moving dune generally extends for some little distance. The width of such spaces depends on the size and shape of the dunes. If barchan chains are 5-10 m in height, for example, the depressions behind the dunes will generally be five metres in width. It is not always advisable to plant or sow in the depressions since new vegetation there can easily be buried by sand. If they serve to stop the advance of dunes, however, several rows of *Salix mongolica* can be planted in those parts of the depressions where sand burial is least likely.

Since soil and water conditions are good in the depressions, *Salix mongolica* will flourish there. The plant resists burial by its strong and spreading root system. As the sand advances, the plant will little by little "climb" the dune and end up by blocking any further advance.

As the dunes become semi-stabilized and the danger of sand burial recedes, the depressions provide the first places in which vegetation can take hold. The vegetation established in depressions is referred to by the people as "three storey pastures". That is because they are composed of trees, shrubs and grasses. To provide protection as quickly as possible, afforestation is carried out with tall cuttings of *Salix matsudana* as the main species. These willows have in recent years been supplemented by poplars – *Populus simonii* and *P. canadensis*. The principal shrub in use is *Salix mongolica*, although in exceptional circumstances, *Salix microstachys* and *Amorpha fruticosa* have also been used. Legumes have included white and yellow varieties of sweet clover, and in recent years, alfalfa and *Astragalus adsurgens*.

Three-storey pastures established in depressions usually show good productivity. Typical yield will be 3,000 kg of browse and fine hay per hectare, although yields have been recorded as high as 5,000 kg per hectare.

Kulums for Fodder and Grass Cultivation

Projects originally carried out to protect grasses in enclosed lowlands were less elaborate to begin with. They have subsequently displayed a marked development, advancing from extensive to intensive management. Indicative of their evolution has been the introduction of cultivation and planting into the construction of grass kulums, concentrating primarily on the sowing of improved fodder grasses. At the same time, attention has been paid to diversify their economies. As a result, kulums have evolved into distinct types.

The forage-grass kulum

The kulum intended for the cultivation of forage and grass is generally built on a relatively small area within convenient distance of a stockbreeding unit. Its purpose is to provide fodder to livestock, these being mainly flocks of sheep.

Kulums of this type are usually established in places favourably endowed with water – on valley terraces, for example, or on moist lowlands between dunes where rain-fed cultivation is possible. They must be manageable with the minimal amount of human labour that typifies stockbreeding. After enclosure, it is the common practice to sow grain crops for one or two years while clearing out noxious weeds. After that, improved grasses are seeded and planted. Proper management is expected to produce a yield of 7,500-10,500 kg of alfalfa per hectare one year after sowing.

Water-grass-forest-cereal four-in-one grass kulums

Kulums of this kind are extensively established in the Ordos region, most of them built on lowlands with favourable soil conditions and posibilities for easy management. Major efforts have gone into constructing them. The measures to be undertaken to establish a four-in-one kulum are as follows:

1) Water resources are developed and utilized. As is characteristic of semi-arid regions, the annual precipitation shows great variation. The rain, when it does come, is concentrated in late summer during the second half of the growing season. Because of the unreliability and seasonal quality of the rainfall, high and stable yields cannot be obtained without artificial watering.

Most of the surface water resources in the region are located in mixed agricultural and pastoral areas in the south. Elsewhere in the region, irrigation must rely on groundwater. At the present time, pipe wells and large-mouth wells are used to bring groundwater out from under shallow layers below the surface. A large-mouth well is in fact an open pond where groundwater is allowed to collect. A pipe well taps water at a depth of 20-30 m.

Although large-mouth wells are inexpensive to construct and produce water at preferred higher temperatures, they take up too much ground for the amount of water they supply and are subject to evaporation. Pipe wells, on the other hand, produce great amounts of water, which is preserved from evaporation until it is used. One pipe well, for instance, yields more than enough water to irrigate 3.3-5.3 hectares. In some exceptional cases, efforts have been made to supplement the water supply by bringing in boreholes or artesian wells that tap water more than 100 m below the surface.

Because the soil is usually sandy with poor water-holding capacity, irrigation canals have to be paved to prevent seepage. This can be done with sod, clay or pre-cast concrete slabs. Tests show that canals lined with tamped clay work well against seepage and are inexpensive to construct. To increase water conservation, plastic sheets have been used in recent years to line canals, and sprinkler irrigation has been installed.

2) Protective shelter belts of trees and shrubs are established. To halt moving sand dunes and prevent damage from drifting sand, shelter belts are planted, usually of *Salix mongolica* supplemented with tall cuttings of *Salix matsudana*, in the form of a loose structure that permits ventilation at ground level. Other trees are included in shelter belts to provide variations in the height of their canopies of foliage. Commonly used are species of poplars and elms. Shrubs, planted to the windward of the trees, include *Caragana* spp., tamarisk and *Amorpha fruticosa*.

Shelter belts not only block the wind and prevent sand drift, they also provide leaves and twigs for fodder. Shelter belts of *Salix mongolica* and *Salix matsudana* yield an amount of green browse and undergrowth that is equivalent to 6,375-7,000 kg of dry matter per hectare.

3) The land is levelled and the soil improved. Irrigation requires level fields, but the land available for kulums may have an undulating surface because it previously contained dunes. If so, it will be necessary to complete the levelling of former duneland and fill in depressions between dunes. In such a case, too, the soil will be too sandy, and clay will have to be mixed with it to improve its physical properties. Not only will better soil raise the crop yields, it will also conserve water. A water saving of 23 per cent was recorded in Otog Banner after the land was levelled and the soil improved.

4) Superior species of forage grasses and grain crops are then sown. At first, four-in-one kulums provide supplementary fodder for livestock. As time passes, they are expected to develop into man-made pastures of high quality.

White sweet clover is commonly sown in the region. It yields 3,525-6,375 kg of hay per hectare in the sowing year, and 5,250-12,000 kg per hectare in the second year, when it also produces seeds at a rate of 1,875 kg per hectare.

In recent years, a cultivated type of *Astragalus adsurgens* has registered good adaptability and high yields. Under irrigation, it yields 75,000 kg of hay per hectare in the sowing year and 27,500 kg per hectare in the second year. The protein content of this hay reaches 16.5 per cent.

The chief grain crops sown in the region are millet and naked barley, with maize cultivated in some places. Millet and barley show yields per hectare of 6,000-7,500 kg, with straw providing another source of supplementary fodder during winter and spring. The harvested field may be used for grazing.

5) Activities are finally enriched by developing diversified economies. Nurseries are established for the cultivation and testing of seedlings and cuttings. Apiculture is developed to provide honey and facilitate the pollenization of plants. Fruit trees and vegetable plots are added to the four-in-one kulum. Medicinal herbs are grown. Veterinary services become available. A wide range of human interests comes to be served in a community based on the sustained yield of the kulum.

INDIA (A)

Implementation of the Plan of Action to Combat Desertification

by

O.P. Gautam*

Introduction

India conceived the problems of the desert and desertification soon after its Independence (1947). When the twenty small administrative units were integrated into the present-day state of Rajasthan, it was possible to co-ordinate the activities of various agencies interested in the development of the desert area and to create a unified Master Plan for the direction, operation and superintendence of all such activities. Attention was further focussed on the deterioration referred to in the First Five-Year Plan which pointed out that "Indian desert of Rajasthan has been spreading outwards in a great convex arc – at the rate of about half a mile per year for the last 50 years". In recognition of the problem, the National Institute of Sciences (now Indian National Science Academy) organized a symposium on the "Rajputana Desert" in 1952, on the recommendations of which the CAZRI was established, firstly in 1952 as the Desert Afforestation Station. This was perhaps the first, and a major, state organized step in the Afro-Asian countries to contain the desert.

The arid and semi arid zone in India is spread over 8 states of the country but 90 per cent of the hot desert is located in north-west India, out of which 62 per cent is located in the state of Rajasthan. It is by far the most populated desert of the world and the manifestations of deterioration of environment are more evident in this region as compared to others. Continuing research work at CAZRI and by other organizations has made the Thar the "best studied" desert in the world.

State-wise Area of the Arid Zone in India

State	Area under the arid zone (sq. km.)	Percentage of the total arid zone in India
Rajasthan	1,96,150	62
Gujarat	62,180	19
Punjab	14,510	5
Haryana	12,840	4
Maharashtra	1,290	0.4
Karnataka	8,570	3
Andhra Pradesh	21,550	7
Total area	3,17,090	-
Jammu and Kashmir†	70,300	–

† Cold aird zone.

Source: A. Krishnan in Desertification and its Control.

* Director-General, ICAR, and Secretary, Department of Agricultural Research and Education, Ministry of Agriculture and Co-operation.

India presented a well documented case study on "Desertification problems in the Luni Development Block" at the United Nations Conference on Desertification held in Nairobi during 1977, besides presenting a Country Report prepared by Department of Science and Technology, Govt. of India. In addition, a compendium "Desertification and its Control" was published by the Indian Council of Agricultural Research, New Delhi. Thereafter, the Arid Zone Association of India, in collaboration with other agencies, organized a post-conference international symposium on Arid Zone Research and Development at CAZRI during 1978 which was attended by 400 participants from 20 countries. It was followed by a post-congress seminar on Anthropology and Desertification which was again held at CAZRI, Jodhpur, in 1978. A number of collaborative projects with international agencies were started to conduct research (with UNRISD) and for developmental purposes (World Bank), which are being taken up on a large scale. The Government of India and State Governments in the arid and semi arid zones realized the alarming situation and reacted in apt manner by taking right decisions, providing funds for anti-desertification programmes, and creating facilities for their perception, for establishing infrastructure to study the problems, for evolving strategies to minimize the hazards and for transfer of technology, as well as having organized result-oriented extension programmes by creating appropriate agencies.

The Indian Desert

The entire area stretching from the Sahara to the Thar appears to be a meteorologically homogeneous one. Besides, physiographic and anthropogeographic conditions of the region are comparable to identical phase in contiguous hot deserts. From a broader view point, the north-west hot arid zone of India is the eastern extremity of 'Great Plain'. In the Indian desert, before the aridity set in, the streams were alive and carried sufficient silt into the sea. Thereafter, the run-off decreased and these streams now flow subterraneally along these dead channels. The confluences of the main channels now form salt basins. This process is still in progress as new salt basins are being formed on lower reaches on the smaller tributaries.

The average annual rainfall of the region varies from 150 to 500 mm with a coefficient of variation as high as 60-70 per cent. The distribution of rainfall is also erratic, occurring mostly in the period July to September. During summer, the mean daily maximum temperature is generally 40°C and 22°C to 28°C during winter. The mean minimum temperature varies from 24°C to 26°C during summer and 4°C to 10°C during winter. The mean diurnal temperature variation ranges from 12°C to 17°C. The mean relative humidity during summer varies from 36 to 50 per cent and from 66 to 78 per cent during monsoon during the morning hours. In the afternoon, however, there is an expected drop and the mean values range from 20 to 35 per cent during summer and 48 to 60 per cent in the monsoon season. The mean evaporation during summer exceeds 10 mm per day. The potential evapotranspiration values during summer (April-June) vary from 7 to 9 mm per day. The mean daily wind speed is recorded to be highest during summer and monsoon seasons, 8-20 km/h.

Arising out of the paucity of rainfall, the surface water resources are also scarce. In the extreme south-west there is an organised drainage emanating from the western slope of the Aravalli that covers about 30,000 sq.km.. Here also in response to rain the actual flow is limited to a few days only. In the north-west there is another small stretch under the influence of the Ghaggar River. In the remaining major part of the tract there are points of run-off and water from them has been intercepted or collected from historic times onward. These, depending upon rainfall, are able to meet the human and livestock needs from a few days to months, after which preforce people have to depend on ground water. The tracts under the direct influence of integrated drainage or those that get recharged through sub-surface flow have reasonably good potential, much of which is already being exploited. Such regions cover nearly 30 per cent of the arid zone. In the rest of arid zone the ground water is too little, too deep and also not quite potable. However, even in this tract the people through a conjunctive use of surface and ground water, are able to sustain themselves, though with considerable difficulty.

The topography of western Rajasthan is not a result of superficial or biogenic agencies, but is attributed to geological processes largely in the nature of the sheet movements leading to peneplanation, rapid changes in the drainage system, enormous accumulation of loose rocky materials, deepening of water table and consequent famishing of vegetation, and thereby accentuation of desertic conditions. A thick sedimentary sequence ranging in age from Early Palaeozoic (or even older) to Middle Eocene is exposed in the western Rajasthan desert. The sedimentation, with many intervening breaks, continued up to Late palaeozoic times till the major uplift and erosion which preceded the next major marine transgression in the Jurassic. The study of the geomorphology of the southern arid zone has shown that two cycles of erosional surfaces are present, one of which is responsible for the accordance of the summits in this area which consist of domes, whalebacks, flat domes, inselbergs, koppies, pediments and pediment passes.

The region comprises a vast stretch of Quaternary alluvial plain and wind sorted sands. Its mean elevation in the east at the foot of Aravalli mountains is generally 350 to 450 m. above sea level and from here the plains slope in easterly and south-westerly directions to an elevation of about 100 m. in the west and 20 m. in the south-west towards the Rann of Kutch.

Most spectacular amongst the land-forms are the dunes. These are present in 58 per cent of the area of the region. Within this, in nearly 30 per cent of the area, dunes proper cover 60 to 100 per cent of the area, in 58 per cent these constitute 20 to 60 per cent of the area. The area of occurrence of dunes lies in the northern and western half of the region but even here it is not a contiguous feature and does have inclusions of dune-free corridors as the area from Pokran through Bap to Bikaner. A variety of dune types such as coalesced parabolic, longitudinal transverse, barchan and obstacle has been recognised. Amongst these parabolic and coalesced parabolic dunes are dominant. The dunes are very variable in height – the common range being 10 to 80 metres and those occurring in Jodhpur and Barmer are the highest. The dunes are highly sandy and contain only 1.8 to 4.5 per cent clay and 0.4 to 1.3 per cent silt. The inter-dunes and associated plains are also light textured, though with more silt and clay. These have a varyingly developed concretionary strata at depths commonly of 40 to 120 cm. There is an appreciable strata of old surfaces having well developed calcrete often with some well rounded rock fragments underneath or exposed at the surface.

The central and southern part of arid Rajasthan is made up of medium and fine textured soil developed from in-situ or alluvial parent material. This region is almost devoid of any signs of deflation or of aeolian sand. These soils are well aggregated and have a good moisture retention capacity. These soils as also those of dunes and sandy plains are somewhat low in nitrogen but well provided with phosphorus, potassium and various other nutrient elements. Though the soils test low in nitrogen, it is not a limitation in establishment and maintenance of good vegetation cover. However, under arable farming application of fertilizer is necessary for optimum yields.

Biogeographically, the majority of the desert biota exhibit Saharo-Rajasthani affinities as opposed to middle-Asian.

The Problem : Deterioration of Desert Environment

Besides climatic vagaries, erratic monsoon and extremes in diurnal temperatures, the Indian desert is confronted with two major problems : escalation of (i) human and (ii) livestock populations. All other processes are in reality the consequences of these two major factors causing desertification and deterioration of the desert environment.

The human population, starting with a base of roughly 3.56 million in 1901, registered a linear escalation and increased to 10.23 million till 1971, almost a threefold increase in the arid districts of Rajasthan. The growth rate (158 per cent) in the hot desert is more than that of the country (132 per cent). The density of population varies from 157 to 4 persons per sq.km. decreasing with the annual amount of precipitation. As a consequence, in western Rajasthan, the cultivation on marginal lands increased by 44.6 per cent during 1951-61 and by an additional 9.47 per cent during 1961-71. Pastures and other types of lands declined by 16.8 and 6.95 per cent during the two decades. The increase in rain-fed farming on marginal lands has not only resulted in a decline in crop productivity per unit area but has also enhanced soil erosion, degraded the soil fertility, and has resulted in over-exploitation of ground water.

The increasing human population is a serious stress, particularly on the vegetal resources of the desert. The trees and shrubs and even their roots are indiscriminately cut by the rural population for fuel, top feed, thorn fencing and the construction of thatched hutments. It has been estimated that the requirements of the people in the desert in respect of the woody biomass has increased from 1.85 million tons in 1951 to 3.33 million tons in 1971. Moreover, the desert people have developed peculiar food habits. All the available air-dried seeds and pods of the trees are used as delicacies. The seeds of *Acacia senegal* (*kumat*), the fruits of *Capparis decidua* (*kair*) and the pods of *Prosopis cineraria* (*sangri*) are harvested. Almost all the fruits of *Zizyphus nummularia* (*ber, jhadberi*) growing in accessible parts of the desert are harvested for human consumption. The seeds of grasses, e.g. *Panicum turgidum, P. antidotale, Cenchrus biflorus* and *Echinochloa colonum,* are mixed with millet for making chapatis (unleavened cakes) especially during drought years. The grass seeds are supposed to add to the nutritive value of the food. The intensity with which seed collection is made for direct human consumption throughout the desert region seriously affects the natural process of regeneration of the desirable plant species in the inhospitable terrain.

In spite of the low productivity of the arid lands, Rajasthan sustains a fairly high population of livestock. Paradoxically, along with the reduction in the grazing area during the last two decades, the livestock population has registered an alarming increase, from 9.4 million in 1951 to 15.5 million (almost double) in 1972. The livestock density per 100 hectares rose from 72 in 1951 to 175 in 1971 in the desert districts but in the adjoining districts, this enhancement was not so spectacular (25 per cent as against 293 per cent in desert districts). The goat and sheep populations ranged from 57.1 to 69.3 per cent during this period. Owing to continued droughts during 1967-71 with the consequent migration and mortality, the number of hardy animals, e.g. the goat, increased substantially (34%). The data thus not only reveal a preponderance of the goat and sheep populations in arid Rajasthan but also point to their increase during the years of drought.

The pressure of livestock on the grazing lands results in the depletion of vegetation resources, and at certain habitats in the desert the natural successional trends have been reversed :

Cenchrus setigerus, C. ciliaris
↓ ↑
Eleusine compressa
↓ ↑
Cynodon dactylon
↓ ↑
Indigofera
↓ ↑
C. biflorus
↓ ↑
Aristida spp.
↓ ↑
Bare sand

Due to severe depletion of food species, the livestock productivity has declined and has induced their migration and nomadism in the human population.

A general approach to improve productivity of arid lands is to bring irrigation water, chiefly for raising crops. Incoming water into a desert also affects the eco-system adversely. It is evident that in Anupgarh Shakha area, the water table is rising at an average rate of 1.52 m per year. At places the rate is 3 m. In Ghaggar flood area water table has risen by 6-9 m. On the basis of water table changes in the Shri Ganganagar district, estimates are that the problem will attain a critical limit with present rate of rise in static water level in about 9 to 275 years in different zones. Besides, the perched water table rise along with sub-surface gypsum bed is also creating severe water-logging hazard.

For collecting rain water for subsequent irrigation, village ponds and dams across prior channels have been constructed in many parts of the Thar desert. These human efforts have also resulted in a deteriorating desert eco-system. They have pushed up the water table and spread salinisation.

Salinity due to construction of tanks has developed in small development blocks. Evidence shows that prior to 1958, an area of 8.3 sq.km. of once productive lands has been salinised beyond use. Since 1958 salinity has spread within this block laterally and during this period an additional area of 15.6 sq.km. has been so effected. It is feared that if the situation continues, the problem would spread to another 40 sq.km. in this block.

Comparison of results of studies carried out in the Luni Block over a period of 18 years (1958-1976) shows that due to human interference, sand movement activity leading to further accentuation of undulation has taken place over an area of 166 sq.km. or 8.4 per cent of the total area of the block. Simultaneously 67.9 sq.km. has undergone deflation. It was also observed that recent sand activities have led to an increase in the thickness of sand on previously created fence line hummocks by 15 to 30 cm and to have enhanced their width by 1-2 metres. The area so affected is 163.3 sq.km. or 8.2 per cent of the total area of the block. The stabilised sand dunes in the extreme north-west also show an increase of sand piling by 1 to 2 metres on the flank and 3 to 5 metres on the crest.

Likewise, in the Rajasthan desert, it is revealed that about 9,290 sq.km. or 4.35 per cent of western Rajasthan has already been affected by the processes of desertification. 1,62,900 sq.km. or 76.15 per cent of the area has been categorised as highly and moderately vulnerable and 41,692 sq.km. or 19.5 per cent of the area is moderately to slightly vulnerable to the various processes of desertification.

Assessment of The Problem

Based on the critical indicators (physical, biological and social), a project on Monitoring of Desertification Processes was formulated by CAZRI in 1978. To cope up with the magnitude of problems related to desertification which show a variety of forms of surface expressions, remote sensing techniques for analysis have been employed. Particularly to study the encroachment of desert in an eastern direction, false colour mosaic of space imageries pertaining to Rajasthan and surroundings were studied for a reconnaissance and semi-detailed appraisal for the perception of sand encroachment. The sands appear in the false colour mosaic as light yellow to green while medium to heavy textured soils appear in dark green to bluish tone. Taking advantage of this tonal differentiation, the areas covered by sand as well as sand-free areas were easily detected, delineated and mapped. It is observed that the bulk of the areas affected by sand dunes and sand sheets occur in the extreme west of the Aravallis up to the Indus River system and Haryana, Punjab and Delhi in the north followed by a discontinuity in the mid-west. Further, sand is also found to be concentrated in pockets around Jaipur, Kuchamana, Dausa, Agra and south of Dholpur. This feature was distinctly reflected in light yellow to light green tone in the false colour mosaic. The Rann of Kutch appears in dark green mottled tone with bluish tinge implying thereby the absence of sand. Ground survey of this area, in 1977, showed no evidence of sand formation either.

From the foregoing it has been deduced that the sand dunes and sand sheets only occur as discontinuous patches from the Rann of Kutch to the north-eastern part of Haryana and Delhi. Further, whatever sand piling has occurred around Jaipur, Agra and Dholpur seems to have originated from intense local biotic disturbances such as improper cultural practices, over-grazing and indiscriminate cutting of trees.

Thus, the discontinuous distribution of sand dunes and sheets in the western sector discounts the transport of sand by wind from the south-west. This has also been confirmed by the comparative study of incidence of sand shown in the ONC (USA) map of Rajasthan and the false colour composite of Landsat for 1977 which do not show any evidence of lateral movement of sand from the south-west to the north-east. Further, in the absence of any sand piling in the Rann of Kutch, the wind-borne theory of sand from the Rann as advocated by some critics (National Institute of Sciences, 1952) appears to be completely ruled out. There is thus no *prima facie* evidence to indicate that desert is spreading towards Delhi-Mathura-Agra region.

Based on interpretation of Landsat imageries (Bands 4 and 5 supplied by ISRO, Ahmedabad), maps on 1:2.5 million and 1:2 million scale have been prepared which also indicate that there are no evidences to show the spread of the Indian desert. This inference is also supported by the socio-economic surveys of the region. Further work is continuing in Haryana and western U.P.

Assessment of vulnerability of smaller area to desertification processes is also an important subject of study at the CAZRI. The band 5 computer printout map depicts the vulnerability to desertification processes of aeolian landforms in a small subscene in the Middle Luni Basin. This feature is reflected in light and dark tone pixels. Analysis of the pixels reveals that the areas of dark pixels due to the presence of vegetation and moisture (brightness value 0–65), which occupy an area of 3.36 sq.km. in the subscene, are least vulnerable to desertification (table, below). The light to dark gray pixels due to moderately sparse to sparse vegetation (brightness value 66–69) indicate areas moderately vulnerable involving an area of 6.07 sq.km. in the subscene. The bright pixels, due to accumulation of fresh sands and no vegetation (brightness value 70–83) constitute the areas highly vulnerable to desertification and seem to occupy the largest area (11.72 sq.km.) in the subscene.

Assessment of vulnerability of areas to desertification in the western part of the Middle Luni Basin (computer printout of Band 5)

Vulnerability	Gray level	Value	Number of pixels	Area in sq.km.	Per cent
Moderate	2–3	66–69	1346	6.07	28.8
High	4–6	70–83	2599	11.72	55.3
			4690	21.15	100.00

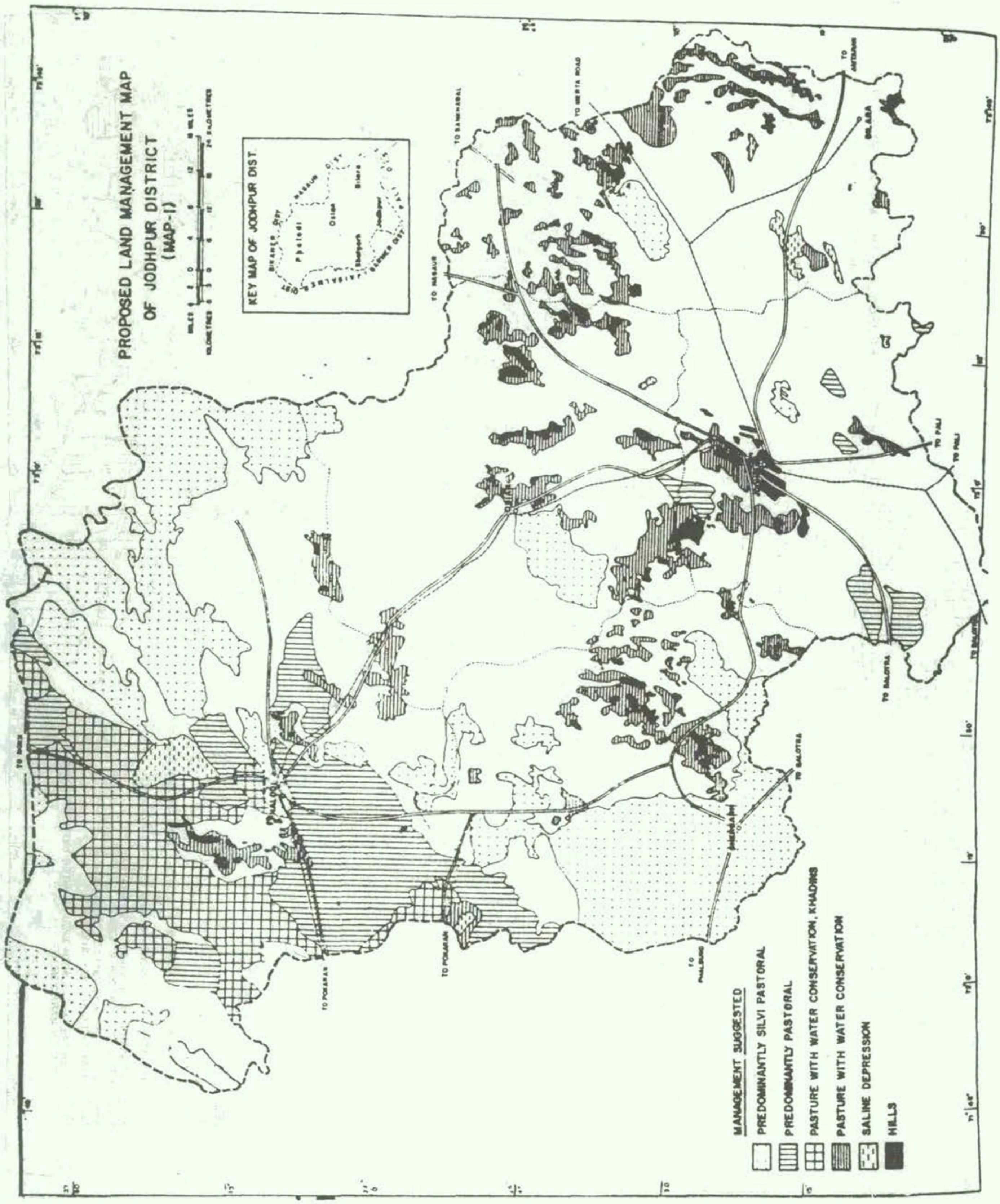
CAZRI has prepared a number of atlases on agriculture in Rajasthan, agro-demography and sheep ecology.

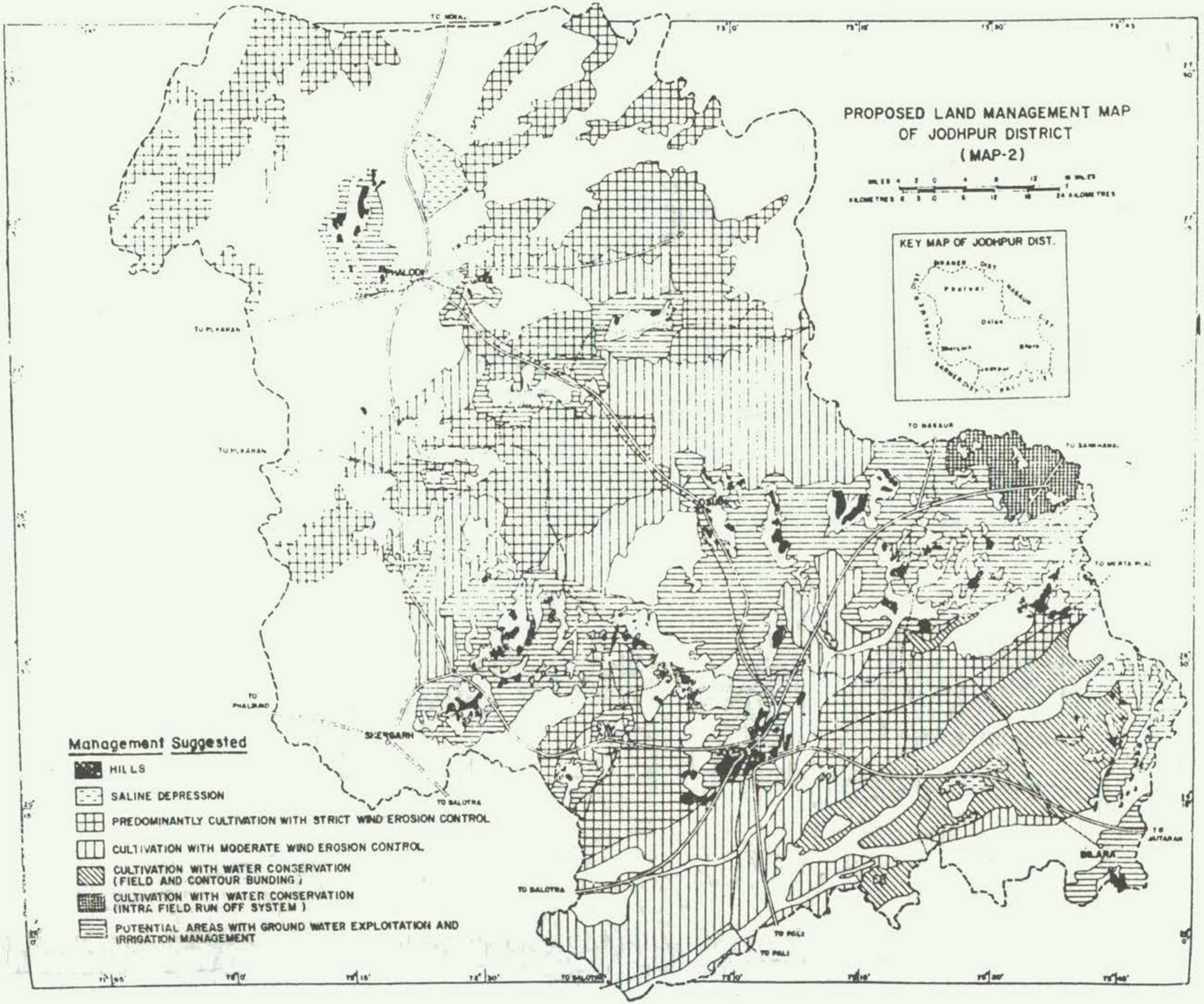
Land-Use Planning and Management

Integrated natural resource surveys are being conducted by CAZRI and that of other bio-physical aspects by several other organizations. The survey areas are selected on the basis of the intensity of vulnerability to desertification. About 100,000 sq.km. area has been covered by CAZRI. These surveys have yielded valuable information for better land-use planning and management. On the basis of evaluation and assessment of physical, climatic and biotic factors, management plans for better land-use practices based on ecologically and economically sound principles have emerged. A number of hazards of technologies to be implemented have also come to light.

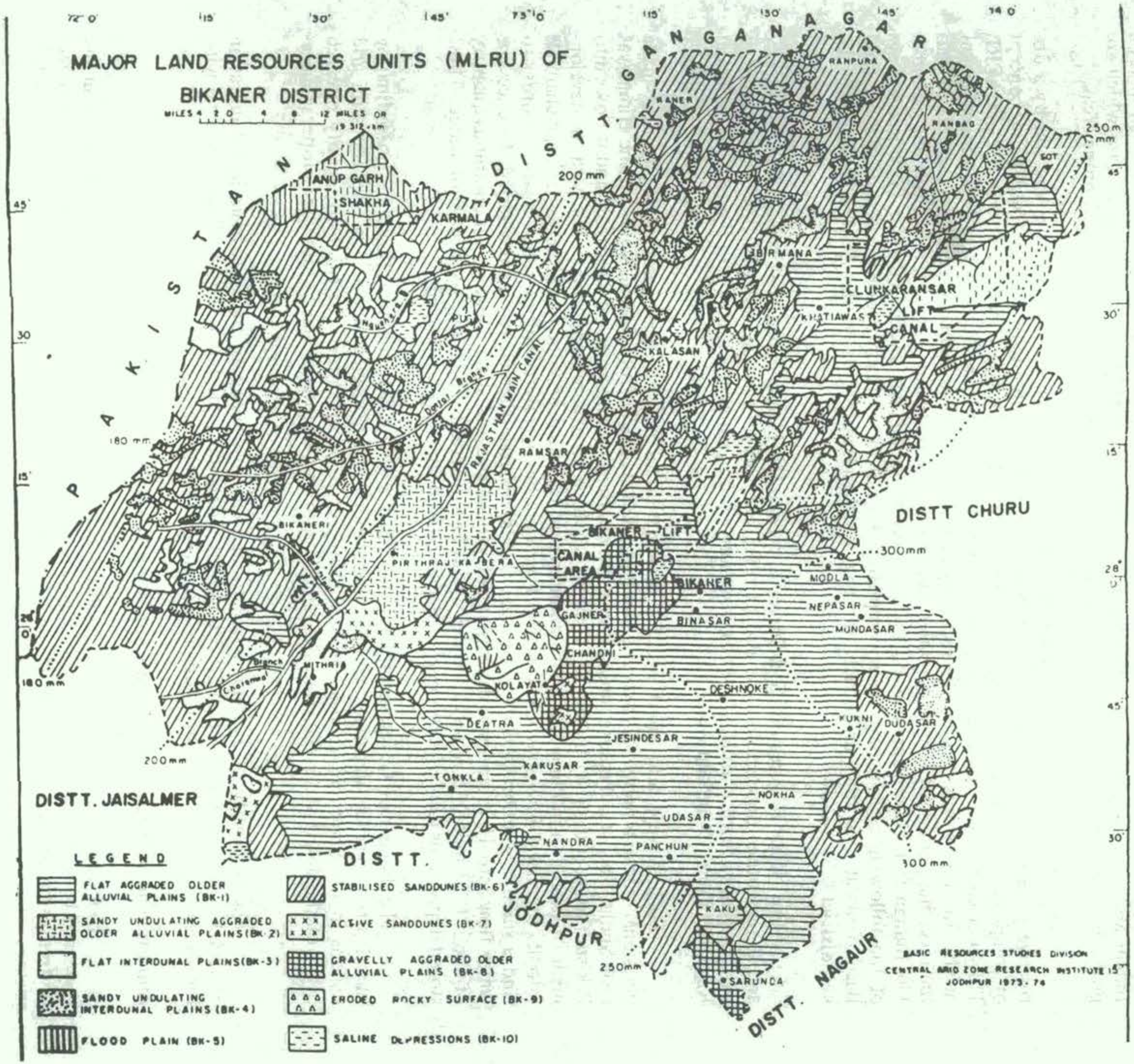
Different soil survey, agricultural and other developmental organizations of Haryana, Punjab and Gujarat are also doing work for land-use planning and management in the desert areas. For carrying out this type of survey the basic data are collected from various sources. The Economic, Statistics and Revenue departments of the various State Governments supply the revenue and statistical and land-use data which are so essential for regional planning. Survey of India, Dehra Dun, is the main source for providing large-scale topographical maps and aerial photographs which are the main tools for carrying out natural resources surveys.

The receiving station of National Remote Sensing Agency (NRSA), Hyderabad, began taking test data from Landsat in August 1979. The station has become operational from January 1980 and users can obtain Landsat data products (70 mm chips, transparencies, colour composites etc.) from


PROPOSED LAND MANAGEMENT MAP
OF JODHPUR DISTRICT
(MAP-I)
KEY MAP OF JODHPUR DIST.
Phalodi
Osian
Bilara
Shergarh
Jodhpur
TO NAGAUR
TO MERTA ROAD
TO PALI
TO BALOTRA
TO POKARAN
PHALODI
MANAGEMENT SUGGESTED
PREDOMINANTLY SILVI PASTORAL
PREDOMINANTLY PASTORAL
PASTURE WITH WATER CONSERVATION, KHADINS
PASTURE WITH WATER CONSERVATION
SALINE DEPRESSION
HILLS



PROPOSED LAND MANAGEMENT MAP
OF JODHPUR DISTRICT
(MAP-2)
KEY MAP OF JODHPUR DIST.
Management Suggested
HILLS
SALINE DEPRESSION
PREDOMINANTLY CULTIVATION WITH STRICT WIND EROSION CONTROL
CULTIVATION WITH MODERATE WIND EROSION CONTROL
CULTIVATION WITH WATER CONSERVATION (FIELD AND CONTOUR BUNDING)
CULTIVATION WITH WATER CONSERVATION (INTRA FIELD RUN OFF SYSTEM)
POTENTIAL AREAS WITH GROUND WATER EXPLOITATION AND IRRIGATION MANAGEMENT
PHALODI
SHERGARH
BILARA
TO NAGAUR
TO MERTA
TO JAITARAN
TO PALI
TO PALI
TO BALOTRA
TO BALOTRA
TO BALOTRA
TO PHALSUND


MAJOR LAND RESOURCES UNITS (MLRU) OF
BIKANER DISTRICT
PAKISTAN
DISTT GANGANAGAR
DISTT CHURU
DISTT. JAISALMER
DISTT. JODHPUR
DISTT. NAGAUR
ANUP GARH
SHAKHA
KARMALA
RANPURA
RANBAG
BIRMANA
LUNKARANSAR
LIFT
CANAL
KHATIAWAS
KALASAN
RAMSAR
RAJASTHAN MAIN CANAL
BIKANERI
PIR THRAJ KA BERA
BIKANER LIFT
CANAL
AREA
BIKANER
GAJNER
BINASAR
CHANDHI
KOLAYAT
MITHRIA
DEATRA
JESINDESAR
KAKUSAR
TONKLA
MODLA
NEPASAR
MUNDASAR
DESHNOKE
KUKNI
DUDASAR
NOKHA
UDASAR
NANDRA
PANCHUN
KAKU
SARUNDA
180 mm
200 mm
250 mm
300 mm
LEGEND
FLAT AGGRADED OLDER ALLUVIAL PLAINS (BK-1)
SANDY UNDULATING AGGRADED OLDER ALLUVIAL PLAINS (BK-2)
FLAT INTERDUNAL PLAINS (BK-3)
SANDY UNDULATING INTERDUNAL PLAINS (BK-4)
FLOOD PLAIN (BK-5)
STABILISED SANDDUNES (BK-6)
ACTIVE SANDDUNES (BK-7)
GRAVELLY AGGRADED OLDER ALLUVIAL PLAINS (BK-8)
ERODED ROCKY SURFACE (BK-9)
SALINE DEPRESSIONS (BK-10)
BASIC RESOURCES STUDIES DIVISION
CENTRAL ARID ZONE RESEARCH INSTITUTE
JODHPUR 1973-74

NRSA. Besides, a large number of application projects are currently in progress at NRSA including natural resources survey, water resources survey and various soil studies.

National Atlases Organization supplies maps of various scales that are useful for basic resources surveys. Indian Space Research Organization and its Space Applications Centre, besides their own research programme, supply sequential Landsat imageries which are very helpful for regional surveys. Indian Meteorological Department is the main source for supply of meteorological data which are probably a primary need for considering developmental planning of arid and drought-prone areas.

Since the approach of mapping the land system as expressed on aerial photographs by a distinctive pattern remains bristled with difficulties in areas with immense biotic activity, a new concept of composite mapping unit – Major Land Resources Unit (MLRU) – has been developed at CAZRI. This unit enables the composite mapping of areas having similar resource potential and management needs. In other words, besides the recurring pattern of soil, land form and vegetation, the MLRU has the receiving pattern of human activities and resource potential of an area for development planning. The human factors are supported by the socio-economic surveys. Integrated natural resource surveys of the following regions have been completed: Rajasthan – Bikaner, Jodhpur, Nagaur, Lower Luni Basin; Gujarat – Santhalpur district; Haryana – Mahendragarh district; and Andhra Pradesh – Chilakeri district.

The National Bureau of Soil Survey and Land Use Planning, National Remote Sensing Agency and a few other organization are also carrying out survey work in various fields. The Rajasthan Government is further utilising the resource surveys in planning the land-use in Upper Luni Basin and Rajasthan Canal Command Area.

Such surveys also point out the acceleration of desertification process due to man-made decisions. Once a perennial river, the Ghaggar takes its origin from Siwalik ranges in the Himalayas near Simla. Its natural course runs through Punjab, Haryana and northern Rajasthan, and it flows into Pakistan to meet the river Indus. The Ghaggar is a dried up river in present times but with the development of irrigation in Punjab, Haryana and northern Rajasthan and due to spilling of drainage channels into it, the flood intensity of Ghaggar in Rajasthan has aggravated during recent years. In order to find a suitable solution to combat Ghaggar floods, the Rajasthan Government diverted the excessive water flow into 18 inter-dunal depressions of various size and shape involving an enormous quantity of about 0.73 million acre feet of water which had disastrous effect due to seepage of water. These stored depressions caused water-logging in about 440 hectares of fertile land.

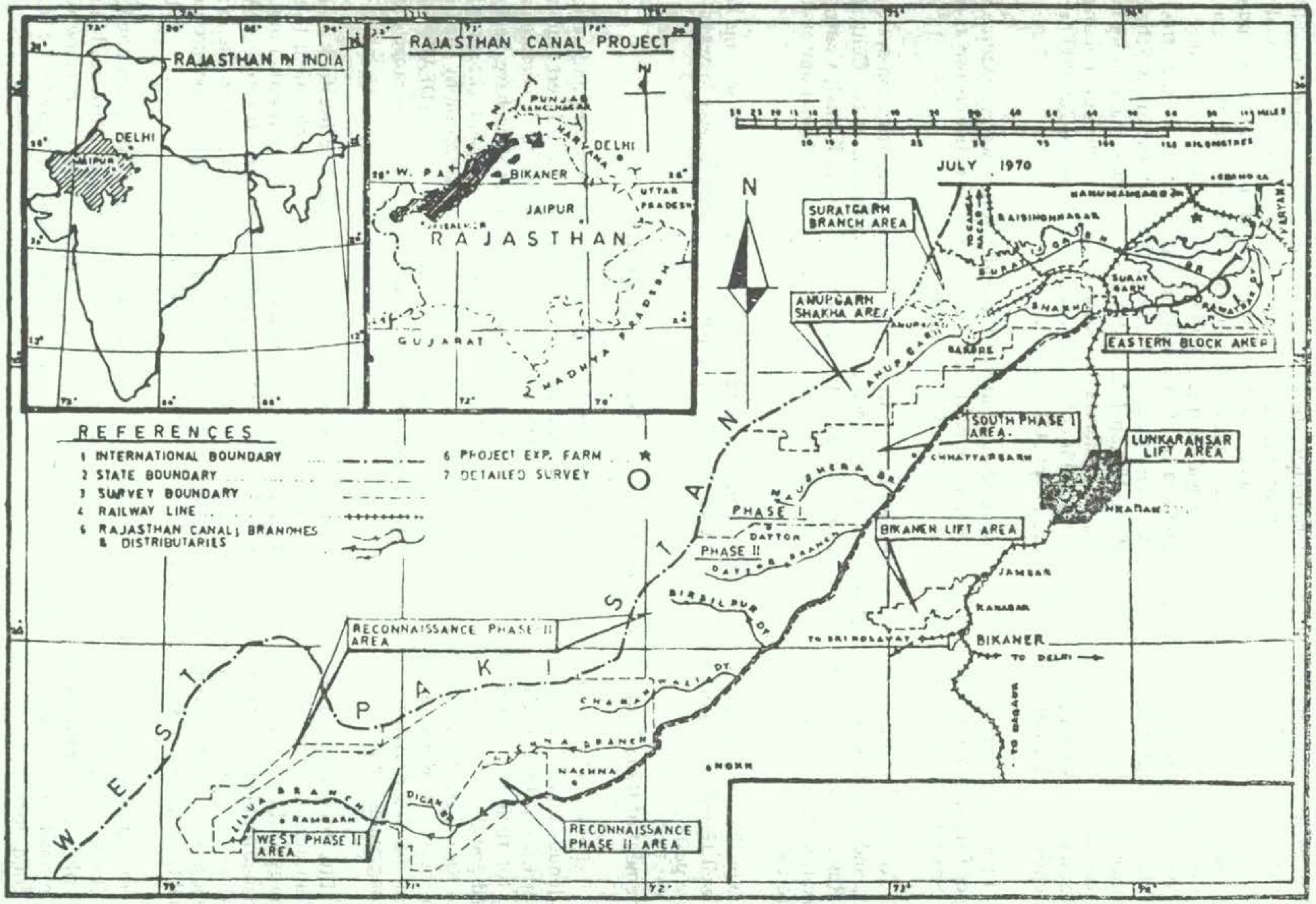
The Rajasthan Government has established a Desert Development Board for co-ordinating the efforts of various departments and organizations and managing land-use in arid and semi arid regions in the State. ICAR has also established the Regional Committee No. 6 to identify research needs of the desert states (Gujarat, Haryana, Punjab and Rajasthan) and to formulate proper management.

The University of Jodhpur is conducting land-use survey of the Luni basin in collaboration of ISRO. The Plant Protection Directorate of Government of India has established a special wing for forecasting the invasion of locusts by advanced remote sensing techniques.

Improvement of Irrigated Agriculture and Water Management

Extensive irrigated agriculture facilities exist in Punjab, Haryana, and northern Rajasthan and these are being further augmented through the construction of the Rajasthan Canal which envisages to transform about 11 per cent of the barren uninhabited areas of western Rajasthan into a vast granary.

In accordance with the Indus Water Treaty and in order to utilize the waters of rivers Ravi, Beas and Sutlej, Rajasthan has been allotted 9,860 million cubic metres of water. To bring this water to Rajasthan 204 kms of Rajasthan Feeder and 445 kms of Rajasthan Main Canal are being constructed. The work was commenced in 1958. Rajasthan Canal has a gross area of 2 million hectares of


RAJASTHAN IN INDIA
DELHI
JAIPUR
RAJASTHAN CANAL PROJECT
PUNJAB
GANGANAGAR
HARYANA
DELHI
UTTAR PRADESH
W. PAKISTAN
BIKANER
JAIPUR
RAJASTHAN
GUJARAT
MADHYA PRADESH
REFERENCES
1 INTERNATIONAL BOUNDARY
2 STATE BOUNDARY
3 SURVEY BOUNDARY
4 RAILWAY LINE
5 RAJASTHAN CANAL; BRANCHES & DISTRIBUTARIES
6 PROJECT EXP. FARM
7 DETAILED SURVEY
JULY 1970
N
SURATGARH BRANCH AREA
ANUPGARH SHAKHA AREA
EASTERN BLOCK AREA
SOUTH PHASE I AREA
LUNKARANSAR LIFT AREA
BIKANER LIFT AREA
RAISINGHNAGAR
HANUMANGARH
SURATGARH
SHAKHA
ANUPGARH
CHHATTARGARH
NAUSHERA BR.
PHASE I
PHASE II
DAYTOR
DAYTOR BRANCH
BIRSILPUR DY
JAMSAR
BIKANER
TO DELHI
TO SRI KOLAYAT
RECONNAISSANCE PHASE II AREA
WEST PHASE II AREA
LILUA BRANCH
RAMGARH
DIGAN
NACHNA
CHARAN WALI DY
RECONNAISSANCE PHASE II AREA
WEST PAKISTAN

which 1.3 million hectares is culturable commanded area. The intensity of irrigation has been kept at 110 per cent. For facilities of construction and administration the project has been split into two stages termed as Stage I and Stage II. Stage I comprises 204 kms of Rajasthan Feeder, 189 kms of Rajasthan Main Canal and 2,880 kms of branches, distributaries, minors, etc. The culturable commanded area is 536,000 hectares which with an intensity of 110 per cent shall give an annual irrigation of 590,000 hectares. Likewise Stage II comprises 256 kms of Rajasthan Main Canal and 4,000 kms of branches, distributaries and minors. The culturable commanded area under flow irrigation in Stage II is 500,000 hectares and under lift irrigation it is 260,000 hectares. Whereas in Stage I there is only one lift canal known as Bikaner-Lunkaransar Lift Canal involving a lift up to 60 metres, and a culturable commanded area of 50,000 hectares, Stage II includes five Lift Irrigation Schemes in accordance with the recommendations of the National Agricultural Commission made in its interim report on desert development. These five lift schemes are Kolayat, Gajner, Phalodi, Pokaran and Nohar-Sawa, involving a lift up to 60 metres and a culturable commanded area of 260,000 hectares. The intensity of irrigation in Stage II has been kept at 92 per cent.

In addition, programmes are in vogue to fully utilize the underground water resource in the Jaisalmer-Chandan-Lathi region in Rajasthan keeping in view the need of its judicious use as recommended by Ground Water Boards of Central and State Governments.

To suit the availability of irrigated water, research work on water use, irrigation system and models, and cropping patterns, salinity and water-logging problems is in vogue at the Central Arid Zone Research Institute, Jodhpur; Central Soil Salinity Research Institute, Karnal; Central Soil Conservation Research Institute, Dehra Dun and in the agricultural and conventional universities in the desert states.

On the basis of intensive eco-toxicological research work carried out on the insect and rodent pests, well tested technologies are available to minimize pre-harvest and post-harvest losses inflicted by these pests.

Improvement of Rangeland, Livestock Production and Wildlife Management

Extreme and intensive studies to establish scientific methods for the upgrading and utilization of the denuded rangeland in different bio-climatic zones and vegetation types in the desert region have been carried out by CAZRI. A number of technologies for establishing pastures, to regenerate natural ranges, for their protection, carrying capacity, stocking rate, and water harvesting have been standardized and demonstrated at about 60 range management and soil conservation paddocks spread over western Rajasthan. Fruitful technologies have also been developed for soil conservation by the Central Soil Conservation Research Institute, Dehra Dun. Drought Prone Area Programme (DPAP) and Department of Desert Afforestation and Pasture Development (DDAPD) have taken up range management programmes in a big way.

Livestock production is a major lifestay of desert people. Although the livestock sector in Rajasthan accounts for 12 per cent of total income of the State and provides employment to about two-thirds of the population, yet the fact remains that the productivity of livestock is rather low. The challenging problem was taken up by the CAZRI, Central Sheep and Wool Research Institute (CSWRI), Avikanagar, and the Animal Husbandry Departments of various desert states. Based on the national breeding policy for improving sheep in the region for enhancing carpet and apparel wool production and quality, intensive cross breeding programmes were taken up at CSWRI.

In addition, a new product – the lamb pelt – has been introduced to raise the economic level of the desert dwellers. Karakul, fat-tailed carpet wool breed of USSR, has been introduced in India. Crosses of Karakul with extremely coarse and hardy breeds like Malpura, Sonadi and Marwari have shown promise for producing acceptable quality lamb pelts. The cross-bred sheep are better adapted to arid conditions.

Improvement in the quality and quantity of wool produced by desert sheep has been achieved through selective breeding of the right types of biochemical polymorphic traits, and by chemically protecting feed proteins from microbial degradation in the rumen. Intermittent (twice-weekly) watering of sheep has been proved to be a better management practice both in terms of sustained or even improved animal production and in almost 50 per cent saving of water.

Goats have been alleged to be 'desert-makers' but physiological and sociological studies taken up at CAZRI and those on forage utilization efficiency aspects at CSWRI have indicated that they can be well utilized for meat and mohair production. These programmes are being taken up on a larger scale. The role of the goat in arid agriculture has been reassessed and its continuance in sufficient number has been advocated.

Appreciable progress has been made during the last seven years in respect of dairy development which has been organized through farmers' co-operatives. At the village level primary milk producers' co-operative societies are organized which, besides collecting milk, also provide technical know-how for increasing milk production which inter-alia includes supply of balanced cattle feed, veterinary first-aid, artificial insemination and fodder seeds of improved variety. A laboratory is established in every society for testing the quality of milk, since payment is made on the basis of fat content. 2,200 dairy co-operative societies have been organized, spread over 19 districts of the State.

The village-level societies have been federated into 11 district-level milk producers' co-operative unions set up on milkshed basis. These unions have established animal health and technical input centres from where inputs are sent to the village-level societies. The mobile veterinary unit visits every society once a week.

The district milk producers' unions have been federated into their apex body, the Rajasthan Co-operative Dairy Federation. The Federation has set up a number of dairy plants and chilling centres to process the milk received from the district unions. It has also set up cattle feed plants for the supply of balanced cattle feed and Frozen Semen Bank to supply frozen semen for cross-breeding of cattle.

Bikaner district has been covered under Operation Flood-I. A feeder balancing dairy of 100,000 litres per day capacity has been set up at Bikaner.

Another similar dairy of 100,000 litres per day capacity has been set up at Jodhpur. Six chilling centres each of 10,000 litres per day capacity were set up at Pokaran, Pali, Balotra, Merta, Loonkaransar and Sardarshaher. The capacity of these chilling centres has been expanded to 20,000 or 30,000 litres per day. The capacity of dairy plants at Jodhpur and Bikaner is also being expanded to 150,000 litres each. New chilling centres are being set up at Barmer, Nagaur, Phalodi, Falna, Rajagarh and Chittorgarh. Under Desert Development Programme a 100,000 litre capacity dairy plant is being set up at Hanumangarh and 20,000 litre chilling centres at Suratgarh, Nohar, Ganganagar and Jhunjhunu.

Wildlife management has also received the special attention of the State Governments of Gujarat, Haryana and Rajasthan, especially in the arid and semi arid regions. It is an encouraging situation that the density of wildlife species in the desert is still appreciable whereas some of them have almost vanished from the country, namely the Wild Ass, *Equus hemionus;* the Black Buck, *Antelope cervicapra;* the Indian Gazelle, *Gazella gazalla* and the Great Indian Bustard, *Choriotes nigriceps.* The three desert states (Gujarat, Haryana and Rajasthan) have declared the establishment of a number of sancturies for preserving the wildlife. A Desert National Park has also been established in the Jaisalmer-Barmer districts in Rajasthan for the conservation of flora and fauna in their native environment. In this context, the Regional Stations of Botanical and Zoological Surveys of India are lending useful support to the programmes.

The Rann of Kutch in Gujarat harbours the only population of Wild Ass, *Equus hemionus.* A sanctuary has been created at Dharangdhara for their protection. After the formation of the sanctuary, their population has increased. A programme is being carried out for ringing flamingoes at their nesting sites.

CAZRI, Agricultural Universities, Departments of Agriculture in the region and the especially established Co-ordinated Project on Dryland Agriculture of ICAR with its 24 centres spread all over the country are engaged in planning and conducting research for evolving strategies for rain-fed farming chiefly pertaining to the following measures:

- Identification of efficient crops and varieties, cropping systems.
- Optimal crop geometry, population, planting patterns.
- Optimal fertiliser use levels and improving efficiency thereof.
- Evaluating mulches, effective conservation procedures.
- Screening available new plant materials for introduction/substitution.
- Designing and developing improved agricultural implements.
- Harvesting and storing inevitable run-off and its recycling strategies for meeting aberrant weather situations.

Based on these major principles, sound crop production strategies have been developed to combat the following aberrant rainfall situations :

- Early onset of monsoon.
- Late onset of monsoon.
- Early recession of monsoon.
- Breaks in monsoon at the seedling stage, at flowering, and grain formation stage of dryland crops.
- Normal and above normal rainfall years.

The standardized technologies are being transferred to farmers through Drought Prone Area Programmes, Operational Research Projects, and Extension and Education Wings of various Institutes, Universities and State Departments. Apex level training courses on Watershed Management are being organized at CAZRI and CSCRI, Dehra Dun.

Notable success has been achieved by the CAZRI in standardizing techniques for establishing rain-fed *ber* (*Zizyphus mauritiana*) orchards in the desert region. A number of orchards established over interdunal plains are doing well in such a cost-worthy manner that arid horticulture has become popular among farmers.

Research work for the utilization of the desert resources, namely organic produce from desert plants, is being carried out at CAZRI. An indigenous know-how has been developed for the extraction and refining of Candelilla wax conforming to cordite factory specifications from the leafless stems of *Euphorbia antisyplitica*. The fruits of an indigenous plant, *Balanites roxburghii*, yield on an average 1.8–2 per cent of commercially acceptable diosgenin–an important raw-material for steroid hormone and oral contraceptives. Scoparone, a drug under clinical trials as a hypotensive and tranquillizing agent, has been isolated in 0.91 per cent yield from the inflorescence of *Artemisia scoparia*. Plantations of Jojoba (*Simmondsia chinensis*) and Guayule (*Parthenium argentatum*) have been established to assess the yield of liquid wax and rubber from these plants.

Sea water irriculture has been successfully evolved at the Central Salt and Marine Chemicals Research Institute, Bhavnagar. It has been possible to grow *bajra* (millet, *Pennisetum typhoides*) under direct irrigation of sea water as a supplemental source of irrigation.

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) at Hyderabad is intensively studying the resource conservation and management aspects in its Farming Systems Research. It serves as a world centre to improve the genetic potential for grain yield and nutritional quality of sorghum, pearl millet, pigeonpea, chickpea and groundnut. ICRISAT has been using mainly soil loss as an index for desertification process. In small plot studies, multi-slot divisions and collection tanks are used for monitoring runoff and soil loss. In watershed based studies, parshal flumes, stage level recorders and automatic silt samplers are generally used for hydrologic monitoring. The effect of different management practices on soil tilth are also being monitored. Based on such studies a number of technologies for double cropping on vertisols and runoff management have been standardized. Improved practices of tillage, seeding, fertilization, crop geometry and pest management have also been studied to improve rain-fed farming in India.

Revegetation of Destroyed Surfaces

Serious efforts have been made to plan, organize and provide funds to improve the desert environment. In 1970-71 the Government of India sponsored a Rural Works Programme for organizing labour intensive and production-oriented works in the drought prone districts of the country which was in addition to the normal developmental efforts in these districts under the State plans. Priorities prescribed in the Rural Works Programme were :

- Major, medium and minor irrigation projects including land levelling and other infrastructure facilities.
- Soil conservation and afforestation works.
- Increase agricultural production.
- Establishment of marketing complexes.
- Village and district roads necessary to open up the area.

Later the scope of the programme was enlarged to an integrated area development scheme to seek a permanent solution of the problems of drought in these districts. Accordingly, the emphasis shifted from labour-oriented to problem-oriented schemes. This programme was designated as the "Drought Prone Areas Programme" (DPAP) in 1972-73. Various components of the programme are :

- Development and management of water resources.
- Soil and moisture conservation measures.
- Afforestation with special emphasis on social and farm forestry.
- Development of pasture lands and range management in conjunction with development of sheep husbandry.
- Livestock and dairy development.
- Restructuring of cropping pattern and changes in agronomic practices.
- Development of subsidiary occupations.
- Development of infrastructure :
  - drinking water supply scheme
  - rural electrification
  - rural roads
  - milk routes

The strategy of DPAP is to maximize the production in good rainfall years and to minimize losses when the monsoon fails. Since the development of agriculture has obvious limitations in these areas, the farmers are encouraged to take up subsidiary occupations like animal hasbandry, poultry, sericulture and horticulture. Development of a comprehensive package of facilities including processing and marketing has been attempted for such subsidiary activities to enable farmers to derive remunerative prices for their produce. Infrastructure for dairying and sheep breeding has been developed to support cattle rearing and sheep rearing avocations. To improve ecology as also to meet the requirements of the local population, both cattle and human, forestry has been taken up relatively extensively. Earlier emphasis was on the development of forest rangelands and restoration of the neglected forests. Rural electrification to assist the exploitation of ground water has been promoted.

The Government of India launched another programme in 1977-78 designated as "Desert Development Programme" for an integrated development of the desert areas for increasing productivity, income level and employment opportunities for the inhabitants through optimal utilization of physical, human, livestock and other biological resources. The schemes covered under the Programme included pasture development, cattle development, dairy development, sheep development, camel development and forestry. For infrastructural development only rural electrification was permitted on a limited scale. Later the element of individual beneficiary schemes were also introduced. The programme was extended to 19 districts (126 blocks) in five States of the country, viz. Rajasthan, Haryana, Jammu & Kashmir, Himachal Pradesh and Gujarat. Of these, 11 districts (85 blocks) were in Rajasthan, the major beneficiary of this programme. This compared with coverage of DPAP extended to 73 districts (401 blocks) in the country (including 18 part-districts) spread over 13 States. Rajasthan again figured prominently in DPAP contributing 79 blocks and 13 districts in the above total. These two programmes have since been running simultaneously in a number of districts. For instance, in Rajasthan DPAP and DDP are in operation in nine districts.

The Government of Rajasthan revitalised the Desert Development Board and established a Department of Afforestation and Pasture Development, which is functioning in an efficient manner. The major components of this revegetation programme and the achievements till 1980-1981 are :

- Farm forestry (1.21 million ha).
- Silvi-pastoral plantation (4,750 ha).
- Village fuel-wood and fodder plantation (2,800 ha).
- Sand dune stabilization (13,850 ha).
- Shelterbelt-cum-roadside plantation (4,304 row km.).
- Pasture development (19,500 ha).
- Fodder bank (10,600 quintal).
- Canal side plantation (3,600 ha).

The proposed financial outlay under the Desert Development Programme for various forestry schemes mentioned above for the plan period has been kept as Rs. 185 million.

The efforestation programme in Rajasthan Canal Project area, which envisages protection of canals, roads and farmlands from shifting sand dunes and supply of fuelwood, timber and fodder, is being implemented with the assistance of the World Bank wihin the project area of 200,000 hectares (Phase I of Stage I). For the remaining 246,000 hectares (Phase II of Stage I), advance action has been initiated. Various works being implemented are shelterbelt plantation along canals and road, fuelwood plantations near villages, sand dune stabilization, and pasture development. The progress of physical achievements during the past years is very hopeful to revegetate at least parts of the desert region. Allocations available for these works during the sixth plan period are Rs. 77 million.

Similar massive programmes are in vogue in Haryana and Gujarat. Strategies have also been developed by the CSMCRI, Bhavnagar, to revegetate the coastal dunes through plantations of plants like Guayule, Jojoba, Juncus and Buffalo Gourd.

Improvement of Human Conditions

Feasible national demographic policies have been laid out by the Government and a very large number of centres for family planning have been established throughout the country. The voluntary programme is backed by a scheme of fairly remunerative incentives. Health of people is very well looked after in Government hospitals and dispensaries which provide free medical care.

Besides population control, steps are being taken for improving general literacy standards, providing diversified base or occupations other than agriculture including agro-industries.

Settlement programmes for migratory and nomadic populations have been evaluated after undertaking intensive research work on their socio-economical aspects, psycho-ethological parameters, traditions, kinship and symbiotic relationships. Employment opportunities for them are also being enhanced.

CAZRI has taken up an extensive study on the social aspects of desertification in collaboration of UNRISD. The project has been successful and has induced a new understanding of the behaviour and traditions of desert people.

Drought Risk Insurance

The DPAP programme, as mentioned earlier, is based on the philosophy of providing insurance from drought risks. The nationalized banks have come forward in a big way to provide loans at low interest rate to the needy farmers.

Strengthening National Capabilities in Science and Technologies

The Food Corporation of India has established large stocks of foodgrains and the Forest Departments of various states have created fodder banks for providing them to drought affected areas.

As an integral part of Indian Science Policy a number of Central and State Research Organizations, Agricultural and Conventional Universities in the arid and semi arid zones of India are functioning to evolve technologies for combating desertification *vis a vis* local conditions and to tranfer them to various implementing agencies and farmers in the rural environment.

Recognising explicitly the pivotal role that conservation plays for sustained national development, the Government of India has created a Department of Environment (DOE) and a National Committee on Environmental Planning (NCEP). DOE is the 'nodal' agency for environmental protection and eco-development and is playing an important co-ordinating role in the planning and implementation of all environment monitoring, intelligence and early warning systems besides having direct administrative responsibility for the following :

- Pollution monitoring and regulation.
- Conservation of critical eco-systems designated as Biosphere Reserves.
- Conservation of marine eco-systems.

These functions will be supported by the NCEP.

Recently, the Government of India has constituted a Science Advisory Committee to the Cabinet. The Committee will advise on the formulation of the science and technology policy of the Government and on the manner of its implementation. Its functions are to recommend measures for increasing the country's technological self-reliance, with particular reference to the Government's policy on foreign collaboration and import of technology, policy issues relating to the development and application of science and technology and organizational aspects of science and technology institutions. Other functions include filling critical gaps in rational competence, promoting technical co-operation among developing countries and other issues concerning science in international relations.

Alternative Energy Sources

Immediate basic requirements of rural areas of India are (a) fuel for cooking, (b) drinking water, and (c) power for lighting, water lifting and farm machinery. The needs of fuel for cooking are mostly met by cutting of trees and burning of cowdung and agricultural waste. The former is the serious cause of desertification and the later deprives the agriculture of a very rich source of organic manure. Drinking water has to be fetched from far-off places. Rural lighting is mostly done by using kerosene whereas power for water lifting and farm machinery is met by manual labour and animal energy, and also from petroleum products, of which there is an acute shortage. Many of the villages are not covered by the national electric grid. Besides, drying of crops is an important requirement. The present practice of courtyard drying is of long duration, unhygienic and results in wastage of about 15 to 20 per cent by birds and infestation. In view of shortage of fossil fuels, alternative sources of energy (solar, wind, biomass) are being investigated by a number of organizations in the arid zone, e.g. CAZRI, Jodhpur, and CSMCRI, Bhavnagar, Defence Laboratory, Jodhpur, and others. CAZRI has designed and developed a number of solar appliances for water heating, cooking, distillation of saline water into fresh water, drying and dehydration of fruits and vegetables. A number of industries have been approached for their large-scale manufacture. CAZRI is also engaged in design and testing of flat plate solar collectors and concentrators, development of heat storage systems and selective surfaces for solar absorbers, and testing of materials for transparent covers, thermal insulation in solar devices. Besides, the institute has also studied the performance of biogas (gobar gas) plants with gas holder (and without) for cooking and lighting. Efforts are also under way to solve the problems in the present biogas plants, viz. corrosion in gas holder, low output during winter and cost.

The use of wind power for various purposes to replace conventional energy has not, however, gained momentum, though research work in this direction is in vogue. A suitable low-cost, sail-wing windmill was developed at CAZRI for pumping water.

Feasibility of solar drying, cooking, distillation of saline water into fresh water, windmills for pumping water and biogas plants is also being demonstrated to the rural community at CAZRI under a PL-480 project. The institute is also co-ordinating the investigations on solar energy utilization in agriculture at CRRI, Cuttack; PAU, Ludhiana; TNAU, Coimbatore, and University of Udaipur.

Government of India has recently set up a High Level Commission for additional sources of energy with full executive and financial powers. Its main task will be to formulate policies and programmes for the development of new and renewable sources of energy. Broadly, the Commission's responsibilities will be (a) to develop appropriate technology for harnessing solar energy, wind energy, biomass and bio-conversion technology, decentralized energy system and other new areas; (b) to function as the national agency for international co-operation in the field of new and renewable energy sources; (c) to interface research and development with production, by promoting acquisition of technical capability and providing finances for design and engineering of pilot plants and prototype production facilities based on locally invented processes and designs and setting up such pilot plants and prototype facilities, wherever required, for rapid commercialization of new and renewable energy technologies; (d) to recommend to the Government various incentive measures for commercial use of new and renewable energy technologies by industries; (e) to function as a data bank and to advise the Government on import of technology in the area of new and renewable energy sources; (f) to be responsible for operating industrial and import licensing policy and procedures as far as the industries in the new area are concerned; and (g) to develop schemes oriented to the needs of rural India, keeping in view the rural sources of energy available.

Training and Education

Central as well as State Governments, and Universities are fully aware of the need for training and educating the rural as well as urban populations in respect of habitat conservation and augmenting the productivity of land. As a result many departments have been established for the purpose. Scientific Research Institutes, Universities and State Departments are regularly organizing training courses for workers in arid and semi arid zones at various levels, with various objectives. The progress of such programmes is fairly satisfactory. Besides demonstrations in respect of a large number of fields are being arranged to educate the rural masses using all the audio-visual aids, TV, satellite TV, cinema and other extension methods. Very fruitful symposia, seminars and conferences are being arranged for exchange of scientific knowledge and technologies among desert scientists.

National Machinery for Combating Desertification

Special mention may be made of two programmes launched by ICAR at all of its Institutes and Agricultural Universities: Operational Research Programmes and the Lab to Land Programme. While the major objective of the first is to demonstrate newer technologies to farmers on their own fields, the latter actually inducts farming families for training and education.

The Jodhpur University is also running a Postgraduate Diploma Course in Desert Technology for Graduate Civil Engineers and Agricultural Engineers. It covers varied topics related to the desert. This course is also taught at the Master of Engineering level.

At present the DPAP and the Desert Development and Integrated Rural Development Programmes function as the co-ordinating and executive authorities in the Thar desert with a scientific backing from CAZRI. However, there is an urgent need that the reclamation and development of the Thar desert be undertaken as a National Project.

INDIA (B)

Arid Zone Research in India

Introduction

Environmental conservation has been attracting global attention for quite sometime. There is a general concensus about the degradation of environment vis-a-vis depletion of natural resources, threat of extinction of important plant and animal species, ever-increasing human and livestock populations, food scarcity etc. It is in this context that the problems of arid regions assume great importance since the arid eco-system is fragile and it is prone to desertification. The unplanned exploitation of natural resources has enhanced the rate of desertification.

The arid regions in general are characterized by low, erratic precipitation, coarse textured soils, shallow depth, low moisture storage capacity, high wind velocity, soil erosion escalation of human and livestock populations etc. which mainly limit production in the arid areas. Besides, there is a great diversity in the magnitude of the problems which individually, or in combination, determine the management of natural resources in the fragile eco-system. The present status of the arid zone research and efforts made to ameliorate the desertic conditions are discussed in this paper.

Extent and Distribution of Arid Regions of India

The arid zone in India covers about 12 per cent of the country's geographical area and occupies over 320,000 sq.km. of hot desert located in parts of Rajasthan (61 per cent), Gujarat (20 per cent), Punjab & Haryana (9 per cent) and Andhra Pradesh and Karnataka (10 per cent). In addition to this, an area of about 70,000 sq.km. of cold desert in Ladakh in Jammu and Kashmir presents an entirely different set of agroclimatic conditions as compared to the hot desert. The bulk of the hot arid areas of the country is located in Rajasthan. Roughly three fifths of Rajasthan lying north-west of Aravallies falls within the limit of arid zone and it comprises the 12 western districts of the State, namely Barmer, Bikaner, Churu, Ganganagar, Jaisalmer Jalore, Jhunjhunu, Jodhpur, Nagaur, Pali, Sikar and Sirohi.

Land Use and Cropping Pattern

The total area of the three states comes to 57.3 million ha which is 18.78 per cent of the total area of the country. The data on the land-use reveal that there is inadequacy of forests in the three states as only 5.11 per cent of the total land in the region is under forests as compared to 21.62 per cent of forest lands in the country.

The barren and unculturable waste lands in the three states together occupy 27.24 per cent of the total land as compared to only 10.58 per cent of such land in India.

Bajra is the main cereal crop in the three states and it occupies about one third of the cultivated area as against 10 per cent area under Bajra in the country as a whole. The cultivated area under Gram and other pulses in the three states constitutes about 10 per cent as against about 15 per cent in the country. 98 per cent of the area under guar crop in the country falls in these three states. Similarly moth is predominantly grown in Rajasthan.

Human Population

By arid zone standards the Indian desert is one of the most thickly populated deserts of the world. Matching with the resources available the density of population of 145 person per 2 sq.km. is quite high. Specifically for the arid parts like that of Rajasthan the density of population is quite high, 48 per sq.km. as against 3 per sq.km. in most other deserts of the world. The States of Haryana, Gujarat and Rajasthan had a total population of 62.4 million in 1971 which constituted 11.4 per cent of the population of the country. The composition and characteristics of the population revealed that 32.57 million (52 per cent) were male and 29.82 million (48 per cent) female. Besides, the human population in the desert appears to be relatively more fertile than that of the adjoining areas. The rate of growth of population (1961-71) in the three States had been of the order of 31.36 per cent, 29.21 per cent and 27.83 per cent as compared to 24.66 per cent decennial growth for the country.

Furthermore, there is a huge concentration of population in the lower age groups which is indicative of high future growth potential of population in the region, and which intensifes the difficulties in meeting the demands of an expanding youth cohort. The literacy rate in the three states combined is only 27.39 per cent as compared to 29.3 per cent for the country as a whole.

Over two thirds of the population constitutes the non-workers indicating a high percentage of dependency. Majority of the workers are tied to traditional agriculture and most of the population specifically in the arid areas of the States are dependent mainly on rain-fed crops. This population is mainly employed during *kharif* season while during the remaining eight months or so is under-employed or unemployed.

Additionally a sizeable proportion of the population leads a nomadic, or semi-nomadic life posing difficulties in regional development as well as in human welfare programmes.

Livestock Pressure

In spite of low productivity of the arid lands, the Indian desert sustains a fairly high population of livestock. Paradoxically along with the reduction in the grazing area during the last two decades, the livestock population has registered an alarming increase, from 9.4 million in 1951 to 18.1 million in 1971. The livestock density per 100 hectares rose from 72 in 1951 to 175 in 1971. The high pressure of livestock on grazing lands specifically in view of its carrying capacity results in the over use of these lands and in depletion of natural vegetation resources. Population has often to resort to migration and nomadic life to meet the needs of their livestock.

The above information and other environmental, biotic and socio-economic factors reveal that the region suffers from a number of problems. The negative socio-economic effects of the fast growing population in the region combined with the harsh agroclimatic conditions are adversely affecting the natural resources. The man/land ratio is fast declining. The improved technology has not been adopted to any significant extent by the farming population. As a consequence more and more marginal land is being brought under the plough, as is evident from the land use statistics resulting into a substantial increase in sown area at the expense of grazing lands. But at the same time the livestock population has increased leading to an over exploitation of the shrinking grazing lands. Crop production on sand dunes and marginal lands is not only of low order but is also a soil erosion hazard.

Similarly, due to the increase in population, not only has more land been brought under plough, reducing the number of trees and shrubs, but also the increasing demand of wood for fuel has led to an over exploitation of vegetation resources. With the persistence of human demands, a process of degradation of resources has set in over grazed lands. Shrinking forests and eroded agricultural fields show the imprints of man's activity on his environment.

Some of the major problems may be summarised as below :–

a) *Environmental constraints :* Low and erratic precipitation; frequent droughts; intense radiation; occurrence of frost; high wind speed; poor soil conditions; limitation of water for human, animal consumption and for irrigation; flash floods.

b) *Biotic :* Pressure of human and animal population particularly on marginal and sub-marginal lands; low plant productivity due to environmental and biotic pressures; damage due to insect and rodent pests.

c) *Socio-economic* : Inadequate exposure to and adoption of modern farming technologies and merits of conservation of natural resources/environment; lack of alternate vocations other than cropping and animal husbandry; fragmented holdings; nomadism, etc.

Initiation of Arid Zone Research In India

The importance of the problems of the Indian desert and its vital role in the development of the national economy was realized soon after India attained independence. The Government of India set up a Desert Afforestation Research Station (DARS) at Jodhpur on 17th October, 1952 under the aegis of Forest Research Institute and Colleges, Dehra Dun. This station was subsequently taken over by the Central Soil Conservation Board in 1954. The station was re-organized as the Desert Afforestation and Soil Conservation Station (DA & SCS) in January 1957.

In 1958 an extension scheme on pasture development was initiated under this station for carrying out research and development work in the extensive range lands of this region and works were started at 52 sites having an area of 60-80 hectares in eleven desert districts of Rajasthan.

Thus the emphasis was shifted from the erstwhile demonstrational aspect to increased systematic research both of fundamental and applied nature in three major fields viz., silviculture, agronomy and agrostology.

Following a request from the Government of India, UNESCO, under its Major Project on Arid Zone, sent an Advisor Mr. C.S. Christian of C.S.I.R.O., Australia, to assess the work done and also to suggest ways and means to re-organize the research for the development of resources on problem-oriented basis.

After a detailed assessment of the problems of the arid and semi-arid regions, Mr. C.S. Christian said that a good start had been made on research in applied science of forestry, agriculture and grasslands, and recommended that in order to develop the use of other resources, as well as to orient the research in relation to problems, a full-fledged research institute should be set up to conduct detailed surveys of basic resources, to carry out research taking the inter-relationship between soil-plant-atmosphere, water and energy and also to study the human-plant-animal relationship.

Accepting the major recommendations of the UNESCO Advisor, the Government of India reorganized this station in to a full-fledged research institute in October 1959 as the Central Arid Zone Research Institute (CAZRI) Jodhpur, to conduct fundamental and applied research on problems bearing on physical animal and human resources and their gainful utilization in order to maintain ecological balance between them. The main objectives of the Institute are given below: –

1. To undertake studies on land, soil, water, vegetation (pasture and tree) resources of arid and semi-arid regions.

2. To obtain an understanding of the amount and fate of water received in the areas in terms of rainfall, condensation, and surface and subsurface flow.

3. To obtain an understanding of the regional dynamics of the landscape, its tendency to change as a result of varying climatic conditions or through use by man and animal and its susceptibility to interference and control.

4. To determine the optimum natural plant community of the major environment in the area in terms of relative densities of adaptive and useful trees, shrubs, ground flora, under varying conditions of utilization.

5. To determine the best use of water and land in relation to:

a) Optimum balance between forest and pasture as well as cultivated crops and animal production.

b) Specific practices applied to each of the above.

c) Optimum level of soil fertility which can be achieved and maintained under varied environments.

d) Specific type and quality of products ultimately useful and favourable to the human community.

e) An assessment of the best grouping of occupations and sources of income.

The Institute is organized at present into seven scientific divisions, viz., Division of Basic Resources Studies, Division of Plant Studies, Division of Animal Studies, Division of Wind Power and Solar Energy Utilization Studies, Division of Soil-Water-Plant Relationship Studies, Division of Economics and Sociology, Division of Extension and Training. Besides the above, main centres of the All India Co-ordinated Research Project on Dryland Agriculture, Co-ordinated Project for Improvement of Millets, Co-ordinating Centre of the All India Co-ordinated Research Project on Rodent Control, Integrated Project for Research on Water Management and Soil Salinity are also functioning as part of the Institute. Two Operational Research Projects, one on "Arid Land Management" and the other on "Drip and Sprinkler Irrigation", are operating at the Institute.

In furtherance of its objectives CAZRI has mainly directed its research efforts firstly to prepare an inventory of natural resources, secondly to develop the technologies not only for the gainful utilization of the existing resources, but also for their supplementation wherever possible and thirdly to transfer the scientific and technological knowledge gained from laboratory and research farms to the field for the benefit of the community as a whole.

The main results of research are as follows:

INVENTORY OF NATURAL RESOURCES OF ARID ZONE

Multi-Disciplinary Integrated Surveys

For making the best use of what nature has provided by way of endowments to the Indian arid zones, it is essential that a through assessment of natural resources is made and a balance sheet of assets and liabilities prepared. In pursuance of this objective, a scientific assessment of natural resources (climate, land, water, vegetation, livestock, human population, etc.) has been made through multi-disciplinary integrated surveys and specific detailed studies. As a result, knowledge has become available for an area of 93,500 sq.km. as follows :–

State	Area covered (sq.km.)			Percentage of the arid zone covered
	Reconnaissance	Semi-detailed	Total	
Rajasthan	32,303	54,379	86,682	44.2
Gujarat	–	1,356	1,356	2.2
Haryana & Punjab	3,516	–	3,516	12.9
Karnataka	2,067	–	2,067	24.7

To enhance the utility of this information in development planning, the land attribute data generated by the above survey are integrated to form major land resource units and each such unit is described for its present land-use, management and productivity, scope for improvement and suggested treatments for realizing the same.

The surveys have also shown the extent to which the present land-use is inconsistent with the land capability. It has been found that 21-24 per cent of the area presently being cultivated needs to be brought under a permanent cover of grasses and trees. The so-called barren rocky areas or magras, that constitute 5.6-8.8 per cent of the surveyed area, can be made to support some vegetation after soil treatment.

To pinpoint problem areas for detailed survey and regional planning, four atlases of Rajasthan have been prepared: Agricultural Atlas of Rajasthan (consisting of 34 maps); Ground Water Atlas of Rajasthan (consisting of 30 maps); Agro-demographic Atlas of Rajasthan (consisting of 18 maps) and Sheep Ecology of Rajasthan (consisting of 11 maps).

A Climatic Analysis of The Indian Arid Zone

A detailed delineation of the arid areas in the country, based on Thornthwaite's moisture indices, has been carried out. Areas with moisture index values of less than 40 were identified as the arid zone. Of the total area (320,000 sq.km.) categorised as arid zone, 62 per cent lies in Rajasthan, 20 per cent in Gujarat, 5 per cent in Punjab and 4 per cent in Haryana. North-western India thus constitutes almost 90 per cent of the total arid zone area in the country. Among climatic parameters, low mean annual rainfall (100 to 450 mm), coupled with high coefficient of variability (40 to 70 per cent) and its skew distribution, extreme variation of diurnal and annual temperature, together with high evaporation have been considered characteristics of the Indian arid zone.

Climatic analogues are defined as regions which are enough alike in respect of soil and climatic conditions. To identify the climatic analogues in India, a map showing 64 soil climatic zones was prepared on the basis of moisture index, thermal index and important soil types. Moisture deficiency patterns in Kharif and rabi seasons were indicated and some maladjustments in the cropping pattern have been pointed out.

Climatic Fluctuations in Western Rajasthan

The climatic types vary from extremely arid to arid and occasionally to semi-arid conditions in different parts of western Rajasthan from year to year. In view of this, the probabilities of occurrence of extremely arid, arid and semi-arid conditions have been worked out. The conditional probabilities for the extremely arid, arid and semi-arid conditions have been worked out using first-order Markov Chain Model. The probabilities can be used to find out the conditions that are likely to prevail with maximum chance during the succeeding year.

Distribution of Rainfall and Rainfall Patterns

The rainfall data recorded at different taluk stations during the years 1901-1970 were analysed and rainfall probability charts were prepared. Maps showing (a) means and parameters of variability and skewness etc. of rainfall; (b) the amounts of excess and deficit rainfall patterns expected once in 5 years and 10 years and (c) percentage frequencies of highly deficient and surplus rainfall years were also prepared. The major rainfall types in western Rajasthan have been identified.

Quantification of Rainfall and Its Utilization Efficiency in Rajasthan

The water use patterns by human and livestock populations and agriculture including grasslands and forests have been worked out district-wise. The rain water use efficiencies were also computed. It was brought out that the land-use pattern in Rajasthan is such that it utilizes only about 50 per cent of rain water even under normal conditions.

Rainfall/Run-off Relationships in The Arid Region Using Dynamic Water Balance Model

The water balance computations for the years 1975-80 were made incorporating the intensity of rainfall, variation of infiltration rate of water in the soil with moisture content and field capacity of the soil under Jodhpur conditions. The study revealed that the run-off and deep drainage losses are in the ratio 1:3 on horizontal soil surface during abnormal years of rainfall.

Systems Analysis Approach for Crop Planning Under Rain-Fed Conditions

In view of high variability in the commencement and duration of growing season, systems analysis was carried out considering early, normal and late commencement of sowing rains. The strategies for crop planning under different systems have been suggested.

Agroclimatology for Crop Planning

On the basis of climatic water balance studies, maps of India showing (a) normal duration of crop growing season with nil or slight moisture stress and its commencement and cessation dates under normal conditions and (b) beginning and end of severe drought period under rain-fed farming were prepared.

Detailed agroclimatological reports of Nagaur, Jodhpur and Bikaner districts were prepared with emphasis on crop planning.

Assessment of Environmental Degradation in Arid Zone

Inherent vulnerability of land and intense biotic pressure have combined to set in a process of deterioration. As a case study different manifestation of this process were quantified in respect of a 2,000 sq.km. area and a report was presented at UN Conference on Desertification. Besides this above detailed study, a generalized map showing vulnerability to desertification has also been prepared for the whole of Rajasthan. The results are summed up in Table 1. Presently, various critical indicators are being tested by the institute as a part of a desertification monitoring programme.

Table 1 : Natural vulnerability and desertification hazard in Western Rajasthan.

S. No.	Units	Area in sq. kms.	Percentage of total area of western Rajasthan
	Natural vulnerability		
1.	Desertified area	9,290.00	4.35
2.	High to medium vulnerable	162,900.00	76.15
3.	Medium to slight vulnerable	41,692.00	19.50
	Total	213,882.00	100.00
	Desertification hazards		
1.	Desertified area	9,290.00	4.35
2.	High	135,292.00	63.26
3.	Medium	67,400.00	31.51
4.	Slight	1,900.00	0.88
	Total	213,882.00	100.00

Arid Zone Soils – Their Characteristics and Properties

The characteristics and properties of western Rajasthan soil have been studied in detail. Dunes are a dominant formation in 30.6 per cent and a sub-dominent associate in 34 per cent of the total area. Light brown sandy soils, associated with a few to many dunes, occur in 34 and 30.6 per cent of the area respectively. Brown light loams, grey brown loams, soils with hard pan, sierozems, alluvial soils with dunes and other soil types identified, occupy 1.7, 13.6, 5.9, 1.6 and 6.8 per cent of the area respectively.

Inherent Fertility Status of Arid Zone Soils

As of now nearly 25,000 soil samples have been analysed for their available nutrient status. The results show that soils are very well provided with potassium, various trace elements and in most situations also with phosphorus. Humus and nitrogen contents are low. Though under cropping, supplemental application of inputs is essential for optimum production, this low level is not a serious impediment in the establishment of a healthy cover of natural vegetation (Table 2).

Soil Salinity

Though few saline depressions are dotted here and there, there are three situations where soil salinity assumes extraordinary proportions. These are (i) the far flood plain of Ghaggar (1,400 sq.km.); (ii) the Rann of Kutch (23,000 sq.km.) and (iii) the south-eastern tract (app. 5,600 sq.km.). These together make 30,000 sq.km. or 11.6 per cent of the arid zone concerned. Of these, the first mentioned problematic area has been found manageable upon availability of canal water. The work done in the Rajasthan Canal Command Area by the Rajasthan Department of Agriculture and C.W.C. has shown that through leaching and paddy-wheat rotation it is possible to reclaim these lands. However, in the case of the other two areas the problem remains intractable. Recent work of CAZRI concerning Pali area suggests that some improvement should be possible here by a combined use of soil working, amendments and ponding of rainwater. Some scope exists also in reseeding with salt-resistant grasses and shrubs, such as have been identified by CAZRI. The Great and Little Ranns of Kutch are largely a saline marsh with ground water salinity even more than that of sea water. Reclamation of this vast saline waste or other alternative use of the Ranns is a problem that remains untackled.

Table 2 : The available nutrient status of the major soils

Soil group	The No. of samples received & analysed	Organic carbon			Available $P_2 O_3$			Available $K_2 O$		
		L %	M %	H %	L %	M %	H %	L %	M %	H %
Desert calcic brown soils	144	89.10	7.90	3.00	25.13	44.43	30.44	23.60	50.70	25.70
Desert soils	4,912	88.30	7.40	4.30	23.00	46.10	30.90	2.10	59.90	38.00
Grey-brown alluvial soils	12,695	80.60	11.10	8.30	22.50	38.80	38.70	14.70	35.20	50.10
Brown soils (saline phase)	2,709	89.30	3.80	6.90	26.30	38.30	35.40	21.10	38.10	40.80
Non-calcic brown soils	1,543	79.00	15.70	5.30	2.50	80.50	17.00	5.50	78.50	16.00
Hilly soils	2,250	72.50	13.10	14.40	30.84	26.84	42.34	15.16	42.15	42.69
Total	24,253	82.33	10.00	7.67	22.54	41.80	35.66	12.37	44.02	43.61

Use of Brackish and Saline Waters in Irrigation

Data in Table 3 will show that nearly 60 per cent of ground water in arid Rajasthan are brackish to highly saline. Investigations have gone on for a number of years to find out the use potentiality of this water and the effects that it has on soil properties.

Table 3 : The distribution of water samples in different salinity ranges in arid Rajasthan

S. No.	Name of district	No. of water samples	Percentage of samples falling in E.C. range (in mmhos)						
			Below 0.25	0.25-0.75	0.75-2.25	2.25-5.00	5-10	10-15	Above 15
1.	Barmer	322	5.9	4.0	10.6	31.4	26.7	15.6	6.8
2.	Bikaner	137	–	1.5	27.0	36.5	31.2	10.2	3.6
3.	Churu	244	–	3.3	16.4	29.5	28.7	14.7	7.4
4.	Jaisalmer	295	0.3	18.6	36.6	19.7	20.3	3.8	0.7
5.	Jalore	505	–	9.5	27.7	29.9	19.8	10.3	2.8
6.	Jodhpur	357	–	7.8	37.6	26.6	16.0	7.8	4.2
7.	Nagaur	459	0.2	7.6	35.7	28.2	21.7	3.8	3.1
8.	Pali	498	–	12.3	33.5	20.1	17.1	9.0	8.0
	Total	2,817	0.8	8.9	29.2	26.8	20.8	8.9	4.6

As a result it is now possible to suggest that with a given quality water and soil type, what crops and what yield can be had and with what management. Though the system is not as remunerative as the fresh water irrigation and it requires some specialized management, the system is quite workable and holds special promise in providing employment during lean periods and insurance against famine condition.

Discovery of the Origin of Salt Basins

Earlier theories of Holland & Christie (salts are wind borne from the Rann of Kutch and deposited in the salt basins) and of Godbole (salts are of marine origin and the basins are the relics of the earlier sea) have been disproved. All evaporites occur along the buried channels; sodium chloride occurs at the confluence points and potassium nitrate, gypsum etc. in the upstreams according to their solubility.

Ground Water Resources

Investigations over the years by various agencies have made the picture of ground water availability reasonably clear. Adequate data are available on depth of occurrence and quality of ground water. Exploratory drilling and geophysical sensing have enabled location of new aquifers, namely the Lathi Basin, the Borunda area, the Sikar Basin and scores of smaller aquifers. It has been estimated that as against the annual recharge or economic mining yield of 2,360 million cubic metres (MCM) in arid part of Rajasthan, only 1,128 MCM or 47.8 per cent is being exploited at present. Tapping of this unexploited potential should enable raising the area irrigated from ground water resources from its present level of 0.55 million ha to 150.85 million ha of cropped area.

Further exploration would help in the location of a few more deep-seated aquifers. However, to safeguard against over-exploitation from these as well as those already under exploitation studies as to actual recharge need to be intensified.

Surface Water Resources

To a large measure, the surface water resources of arid zone are being exploited already to augument domestic supply and to provide limited irrigation, for example Jodhpur district has 10 reservoirs with a total capacity of 122 MCM and 292 big and medium sized 'nadis' (Table 4).

Table 4 : Existing surface water storage of Jodhpur District.

S. No.	Tehsil	Major and medium reservoirs		Medium and big nadis		Water need for human & livestock MCM
		No.	capacity MCM	No.	capacity MCM	
1.	Jodhpur	5	48.99	93	7.91	9.31
2.	Bilara	3	54.20	66	4.40	5.50
3.	Phalodi	1	8.76	42	2.54	4.23
4.	Shergarh	–	–	42	2.27	3.50
5.	Osian	1	9.96	49	3.54	4.73
	Total	10	121.91	292	20.66	27.27

Nearly 40 per cent of the stored water is amenable to evaporation and therefore the 'nadis' are able to meet only 45 per cent of the domestic requirement. Survey has shown also that there are 24 catchments with a run-off potential of nearly 43 MCM. The run-off from these presently goes to recharge ill-defined aquifers. Through suitable structures, it should be possible to harness it for more effective use. Besides the above, nearly 0.11 million ha have scope for adoption of soil and water conservation measures.

A systematic study is in progress to work out the surface water potential of the only organized drainage system in arid Rajasthan, namely the Luni system. Results obtained so far suggest the promise that artificial recharge methods hold for the area.

Recognition of Prior Drainage System and Its Significance

Pioneering studies carried out at the CAZRI have enabled reconstruction of prior drainage system as it existed before the onset of aridity and its resultant disorganization. It has also been found that the drainage lines are the potential and perennial sources of ground water.

Very recently it has been possible to discover the lost courses of the Vedic Saraswati. It is seen that the Luni and the Drishadvati system were tributaries of the Saraswati flowing through the Rajasthan desert. These systems were again tributaries of the Satadru (the Sutlej) which used to meet the Saraswati at Sirsa, Jakhal, Hanumangarh, Anupgarh etc. Eventually the Saraswati and the Satadru shifted westward and severed their relation. The Satadru amalgamated with the Indus and the Saraswati was flowing independently through the western part of Jaisalmer division.

AFFORESTATION AND WIND EROSION CONTROL

One of the important techniques to control the spread of desertic conditions is afforestation including establishment of wind break and shelter belts to provide mechanical obstacles to the free sweep of wind so as to reduce its velocity. Such obstacles besides reducing the wind velocity and the soil erosion, also reduce the evaporation from soil by minimizing the desiccating effect of wind. Another important measure in this direction is the stabilization of shifting sand dunes. The following techniques have developed to check the wind erosion.

Sand Dune Types and Their Dynamic Characteristics

In the arid zone of Rajasthan sand dunes with varying frequency are spread over 58 per cent of the area. Their extent and distribution have been mapped. These dune bodies have been studied for shape, size and genetic factors and from this six distinct types have been established. Of these, four types, namely parabolic, coalesced parabolic, longitudinal and transverse, belong to the old system. They are not unstable and some vegetation cover is present. However, the dunes of the new system (barchans and shrub coppice) are unstable and hence hazardous. These need afforestation as a priority.

Sand Dune Stabilization

Unstabilized sand dunes shift their locations not only to encroach over the roads, railway lines, villages and clog the irrigation canals, but the drift sand also covers the saplings of food crops, occasionally in vast stretches of cultivated desert lands. Techniques for sand dune stabilization have been evolved. The rehabilitation of marching sand dunes through revegetating involves three distinct processes viz., (a) protection against biotic interference by fencing the area (b) establishment of micro wind breaks on the windward side of dune in 5 m parallel strips or 5 m chess boards, and (c) sowing of grasses and transplanting (with the onset of monsoon of adapted trees and shrubs raised in earthern bricks on the leeward side of micro wind break.

Economic analysis of this stabilization has indicated that the average cost of Rs. 760 per ha will be rapaid after the end of the 13th year.

It has been found that about 50 to 70 mm of moisture initially present within a metre depth of unstabilized dunes helps in the seedling establishment. Moisture received in the monsoon helps for seedling establishment and subsequent growth. Soil analysis after few years of establishment indicated that this technique influences the organic matter build in the sand dune.

SHELTER BELT AND WIND BREAKS

High wind velocity (up to even 40 km./h.) and soil erosion are manifest from May to June/July causing great danger to sown crops. To mitigate the ill effects of high wind velocity, not only has the concept of shelter belts been developed but also the composition of trees and shrub species for establishment of five-row shelter belts has been standardized in various permutations and combinations in order to impart a pyramidal cross section. Following the technology, shelter belts of *Acacia nilotica,* sp. *indica* and *Dalbergia sissoo* have been successfully established over 102 km. at the Central Mechanised Farm, Suratgarh in Bikaner Division of western Rajasthan. Moreover, experimental shelter belts in the form of roadside avenues along the principal highways were established in different parts of the region to the extent of 200 km. at a cost of Rs. 1,200 per row/km.

The effectiveness index of tree shelter belts of *Cassia siamea, Acacia tortilis* and *Prosopis juliflora* in wind speed reduction was computed and it was found *Cassia siamea* and *Acacia tortolis* shelter belts are useful in controlling wind speeds.

The crop shelter belt of bajra provided to summer vegetable crops was found to be instrumental in modifying the crop microclimate and increase the yield by about 40 per cent in respect of Bhindi and Cowpea. It is further suggested that (a) the areas unsuitable for agriculture and where wind erosion is an acute problem should be put under grasses, trees or a mixture of both; (b) the areas which are suitable for agriculture should be protected from wind erosion by following such practices as addition of organic matter, pond sediments etc. so that there is development of soil structure which makes the soil more resistant to erosion; (c) crop barriers and shelter belts should be used for checking wind erosion and reducing the effect of desiccating winds; (d) strip cropping techniques should be followed, perpendicular to the direction of wind; (e) such practices as leaving crop residues and stubble in the field, providing surface cover of mulches etc. should be followed and (f) cultivation and planting of a dry soil leads to breaking of clods and more erosion and, therefore, should be avoided.

ARID SILVICULTURE

The most urgent practical problem in applied silviculture is the development of practical methods for afforesting different land types met within the arid zone with suitable species. The significant work has been on; (i) selection of suitable tree and shrub species both indigenous and exotic and their eco-types for different sites; (ii) production of seedling transplants; (iii) silvical characteristics of selected tree and shrub species; (iv) soil working techniques and cultural operations in relation to harnessing otherwise uncertain and erratic rainfall, particularly during periods when lack of soil moisture is more felt and (v) protection against disease and vertebrate pests.

Introduction and Selection of Fast Growing Tree Species

The local tree species of the region are not only few but are also extremely slow growing. Therefore, greater attention was focused on introduction and selection of exotic fast-growing tree and shrub species from iso-climatic regions of the world. In this effort about 112 eucalyptus species 65 acacias species and 82 miscellaneous ones from various countries including Mexico, USA, Latin America, USSR, Africa, Israel and Middle East were introduced. As a result a number of exotics tree species like, *Eucalyptus camaldulensis, E. terminalis, E. melanophloia, Acacia tortilis, A. raddiana, A. seyal, A. sieberiana, A. aneura, Colophospermum mopane, Dichrostachys glomerata, Brasilettia mollis, Schinus mollis* and *Prosopis juliflora* (provenance Israel, Peru and Chile) have emerged as very promising for arid region. Of all the exotics *Acacia tortilis* has been adjudged the best fuel-cum-fodder species for dry zones and when felled in the tenth year of planting is estimated to yield 40 tons of air dry fuel per hectare. It has found a niche not only in western Rajasthan but also in other States including Punjab, Haryana, U.P., M.P., Gujarat Tamil Nadu, Haryana, A.P., Orissa, Bihar, Maharastra, Karnataka, Delhi, J. & K, W. Bengal and H.P. The seed and plant material of *Eucalyptus camaldulensis* supplied from CAZRI has been grown extensively by Andhra Pradesh State Forest Corporation and great demand for it has since followed from Tamil Nadu, Rajasthan, Gujarat and Haryana Forest Departments.

Acacia salicina, A. aneura, Brasilletia mollis Hardwickia binata and *Colophospermum mopane* have been identified as fodder trees most suited for 300-350 mm rainfall zone. Whereas *Dichrostachys glomerata* has been adjudged the best species for reclamation of wastelands in view of profuse root suckers produced by the plant.

Production of Seedlings

Nursery techniques for raising plant material of both indigenous and exotic tree species have been standardized and include the use of (i) a well balanced potting mixture of sand, farmyard manure, and clay in equal proportion; (ii) cylinderical mettalic bottomless containers; (iii) watering at nine litres at a time per set of 50 containers; (iv) providing overhead shed during hot season; (v) construction of cemented beds and (vi) raising of live wind breaks around the nursery.

Silvical Characteristics of Selected Tree and Shrub Species

The results of silvical studies on the important arid zone tree and shrub species indicated that under rain-fed conditions the transplanting of 6-9 month old seedlings gives a significantly better performance than seeding at site or the transplanting of two year old plants in 60 cu.cm. pits excavated and refilled with weathered soils. Thus in arid region younger seedlings successfully withstand the physical limitations of the environment. The planting of yound seedlings, instead of the general practice of using older transplants will, therefore, substantially reduce the cost of production of nursery stock. Planting at different periods did not show any marked affect on the seedling survival and growth in height as the establishment depends mainly on the rainfall pattern. The best planting period synchronises with the onset of monsoon. Compared with direct seeding, transplanting proved to be an assured method of reboisement. It is better to follow an initial wider spacing of 5 x 5 m for conducive plant growth and to obviate the necessity of early thinning.

Soil Working Techniques and Cultural Operation in Relation to Land Type

Soil working techniques and cultural methods for establishment of plantations in different land types have been developed as follows:

- Shallow soils: Studies on afforestation of shallow soils (22.5 cm depth) over line hard calcareous pans under rainfall of 375 mm showed that two weedings, one at the end of the July and the other at the end of January are extremely necessary for proper plant growth. Perforation of the pan to a depth of at least 90 cm is also extremely necessary for obtaining increased tree growth.

- Semi-rocky areas: In semi-rocky areas, the soils are characterized by their shallow depth at the foothills in the 225 to 350 mm rainfall tract and are formed by colluvial silt and rock fragments. Among the different soil working techniques tried, staggered contour ridge-cum-trench, each 2 m in length and 60 x 60 cm in cross section, proved successful.

- Rocky areas : Barren rocky hills, covering extensive areas form one of the characteristic features of the landscape. Studies show that only those patches where about 45 cm depth of soil has accumulated should be planted with tree species. Pre-sprouted stumps of *Prosopis juliflora* in half-filled pits of 60 x 60 cm and direct seeding of *Acacia senegal* on ridge have given quite good establishment.

Protection Against Disease and Vertebrate Pests

Not many tree species were observed to be affected by disease in the region except *Delonix regia* and *Eucalyptus gomphocephala saplings* which were found to be affected by a fungus, probably species of *Fusarium.* The affected trees when treated with Bordaux Mixture showed signs of recovery.

Among the vertebrate pests, the most common are *Baselaphus tragocamelus* (nilgai), *Gazella Gazella bennettii* (chinkara), *Capara species* (common goat) *Lepus nigricollis* (hare) and *Meriones hurrianae* (Indian Desert gerbille). The most effective mechanical repellant for the first three species of pest is fencing with angle iron posts and barbed wire. The ecology and control of the most obnoxious rodent pest has been worked out in detail.

ARID HORTICULTURE

Fruit plants adapted to various agro-climatic conditions have been identified. Improved varieties of ber (*Zizyphus mauritiana*), such as seb, gola and mundia have been selected. Of these gole is early maturing and its berries become available for marketing by end of December, when no other improved varieties are available in the north-eastern belt.

A new technology developed has cut short the time for raising ber orchards from the normal one year to only 4 months. The grafted plants are raised in polythene tubes in which root stock is ready to receive scion in 90 days.

Further in order that this benefit may percolate to grass roots of desert dwellers, a field-scale programme of budding of gola and seb on the root stock of common local bush *Zizyphus nummularia* was initiated and has had a good impact on the farming community.

Water harvesting techniques for assured establishment of ber orchard and maximized fruit production along with infiltration characteristics in relation to slope and anticedent soil moisture have been standardized and perfected.

Post harvest technology by way of manufacture of jam, squash, ber preserve and dehydrated ber etc. from ber fruits has been standardized.

For the safe long distance transport of grafted ber seedlings, an innovative device called "poly-back" has been developed.

POTENTIALITY OF NATURAL VEGETATION

The vegetation – trees, shrubs and grasses – such as is encountered in arid zone is quite well adapted. These are deep rooted, tenacious enough to survive extended droughts and yet efficient to put on good bio-mass during favourable interludes. These are quite palatable, fairly nutritious and rich in mineral matter including trace elements. Moreover, there is a great variety with as many as 107 species of grasses alone.

As a result of surveys, eco-types with more favourable economic parameters have been identified. With all these studies one fact comes out strongly i.e. the present low productivity from our open grazing lands and orans is because of persistent over-grazing and consequent diminution of high yielding, useful perennial species.

Besides the above, 96 species of grasses, shrubs and trees of use during period of famine and 108 species with medicinal value have also been identified.

Under-Exploited Tropical Plants

Plantations of little known economic plants such as *jojoba (Simmondsia chinensis), guayule (Parthenium – argentatum) candelilla wax (Euphorbia antisyphilitica)* have been established.

Economic Products from Desert Plants

An indigenous know-how has been developed at CAZRI for the extraction and purification of candelilla wax from *Euphorbia antisyphilitica* stems which finds an end use in the manufacture of explosives.

Raw Materials for Pharmaceutical Industry

Diosgenin which is a raw material of choice in the production of sex hormones anabolic agents, corticosteroids and oral contraceptives has been isolated from the fruits of indigenous desert plant *Balanites roxburghii.* Diosgenin content averaged 1.8 -2.96 per cent of commercially acceptable quantity.

Other materials extracted in workable yield are Scapolamine (0.3 per cent) from leaves of *Datura innoxia* used in controlling tremor in Parkinsonia disease, Scoparone a tranquilising agent from the inflorescence of *Artemesia scoparia* distributed wild in Palsana-Jhunjhunu region.

Iso-hexenylnaphthazarine a new class of drugs evaluated for anti-cancer activity in USA, have been successfully isolated in *Arnebia hispidissinea* a common local desert herb.

Besides rotenone, the most effective insecticides among rotenoids have been isolated from the common desert herb *Tephrosia villosa.*

PASTURE MANAGEMENT AND IMPROVEMENT

Cultivated Pastures

A number of high yielding cultivars of grasses viz., *Cenchrus ciliaris, C. setigerus, Lasiurus sindicus, Dichanthium annulatum, Panicum antidotale* for different agroclimatic regions have been identified and their productivity assessed. Perennial fodder legumes like *Dolichos lablab* and *Clitoria ternatea* for cultivation as pure crops as supplemental feed for animals have been identified. Agronomic practices like tillage, time of sowing, method and depth of sowing, seed rate etc. for the above grass and legume species have been standardized.

Pasture Utilization

Studies conducted on the carrying capacity of natural and sown pastures reveal that natural pastures can sustain only one sheep per hectare whereas in a sown pasture three sheep can be maintained per hectare on year-round basis without deterioration of pasture. Mixed pasture of *C. ciliaris* and *C. setigerus* gave maximum growth weight (17.5 kg) in ram lambs born in July-August in average 100 days. The animals fed on cultivated pasture give higher percentage of dressed meat (46.8 per cent) and muscle protein (5.8 per cent) compared with those on natural pastures (43.2 and 4.4 per cent respectively).

Water Harvesting Techniques in Rangelands and Pastures

A tractor drawn "pitting disker" was fabricated which has been found to be a very effective and cheap method of water harvesting on range and pasture lands. While the working cost of this implement is nominal (Rs. 27 per ha) the use of it increases the forage yield to the extent of 83.04 per cent and 52.90 per cent in natural protected rangeland and re-seeded pasture respectively.

Looking to its impressive performance, DPAP has adopted it for use in its Pasture Development Paddocks at Jodhpur and Nagaur districts.

RANGE MANAGEMENT PRACTICES

Improved practices for raising the productivity of rangelands have been identified. It has been recognized that because of heavy livestock pressure, it is not possible to have a successful range management programme without proper fencing. Angle-iron posts with a fencing of barbed wire is by far the most effective and economic means in the long run. Unwanted thorny plants should be grubbed out mechanically, followed by the application of the herbicide 2-4-5, T immediately after cutting away the aerial parts of the bushes. With a view to improve livestock production, providing shade for grazing animals and the top-feed during the lean periods, it is imperative to introduce some suitable top-feed tree species. A good pasture may have about 30 such trees per hectare.

Soil conservation measures increased the forage production significantly. The average increased yields, as a result of contour furrowing, contour bunding and contour trenching, were of the order of 638.7, 168.8 and 165.0 per cent respectively per year. Contour-furrowed plots were found to contain more available soil moisture than that of contour bunded or contour-trenched plots.

A technique of re-seeding the grasslands has been perfected. The technique consists of selection of suitable species for different agro-climate regions, re-seeding the mixture of *Cenchrus* species and *Lasiurus sindicus*, and *Cenchrus* species and *Dichanthium annulatum* in low and high rainfall areas respectively, at the rate of 5-7 kg/ha and drilled uniformally in rows spaced at 75 cm apart in furrows 8-10 cm deep at a depth of 1-3 cm, and two weedings done during the first year of establishment.

Grazing in rangelands with climax vegetation should be regulated by dividing the area into suitable blocks for practising rotational grazing. Studies on fertilization of rangelands have revealed that increased yields of forage of the order of 50 to 70 per cent could be obtained by application of 20 kg N/ha. The protein content of forage of fertilized pasture was higher than in the control plots. Application of nitrogen at the rate of 20 kg/ha in areas with annual rainfall of 300 mm and below, and 40 kg/ha in areas with an annual rainfall above 300 mm, is recommended.

Provision of drinking water and preservation of forage for the lean periods/years are other important considerations in improving the productivity of rangelands. The Institute has done useful work on all these aspects.

ANIMAL PRODUCTION

Physiological Reactions of Sheep and Goats to the Hot-Dry Environment

Research on livestock production in relation to heat and water stress conditions have revealed that indigenous breeds of sheep (Marwari and Magra) and of goats (Barmeri and Parbatsar) are physiologically well adapted to the dry hot conditions of western Rajasthan. The major avenue of heat loss in sheep seems to be through the respiratory tract, while the goat relies both on surface and respiratory heat exchange. The exotic Corriedale sheep and cross bred goats (crosses of Alpine and Saanen with Beetal and Jamnapari) showed wide variations in body temperature, respiration rate and pulse rate between morning and afternoon in summer in sharp contrast to indigenous sheep and goats. The Corriedale and the cross-bred goats are, therefore, not suitable for the desert region. Of the five desert sheep breeds examined, the Marwari is the hardiest, followed by the Magra. The Barmeri goat is even more tolerant of heat and water stress conditions than the sheep.

Long-term intermittent (twice weekly) watering of Marwari and Magra sheep has resulted in considerable increase in body growth and wool production rates in these animals. A net saving ranging from 50 to 60 litres per month per adult sheep and about 25 to 30 litres per month per lamb could be achieved by watering the animals twice weekly instead of watering them daily. Dehydration in these animals induces urea recycling almost immediately. During water restriction periods, the goats conserve water by reducing the urine volume. The goat is akin to the camel in maintaining the fluidity of the blood during water stress. Even when drinking relatively saline (1.5% NaCl) water for more than three weeks, Barmer goats maintained normal plasma and blood volumes indicating normal circulation of blood.

Breeding Sheep for Finer and Heavier Wool

Attempts have been made to develop a biochemical approach to sheep production to obviate the delay inherent in the time consuming conventional method of selection based on performance tests. Studies conducted so far point to haemoglobin A (HbA) and low glutathione (GSH^H) type animals as producers of heavier wool and low potassium (LK) and Hb A type animals as yielders of comparatively finer fibres, in comparison to animals of any other traits examined.

Sheep Reproduction Under Hot, Arid Conditions

A simple technique, involving a single dose of testosterone enanthate for the induction of libido in inactive adult rams has been evolved. Both male and female Marwari sheep, and possibly those of other desert breeds, are characterized by the non-seasonal nature of their reproductive characteristics. This physiological flexibility makes it possible to plan breeding programmes in accordance with climatic variations, feed resources availability, and market demand.

Considerable information regarding adaptive, productive and reproductive performance of Australian Corriedale sheep managed under arid conditions has been generated. While the Corriedale rams do not suffer from "summer sterility", they are physiologically ill adapted for the region, and hence their extensive use for flock improvement in this region may not be feasible.

An Improved Nutritional Technique for Increasing Wool Production

In the arid and semi-arid parts of India, the leaves of the thorny plant *Zizyphus nummularia* (locally called *bordi pala*) constitute an important protein-rich roughage and are of special value as drought feed. A simple chemical treatment, involving dilute formaldehyde solution, of these leaves (pala) has proved to be very effective in inducing increased wool growth when the treated leaves are fed to the animals in small quantities daily. This chemical protection of feed proteins from ruminals degradation and the subsequent more efficient utilization has considerable possibilities in the field of animal production.

The percent chemical composition and true dry matter digestibility (TDMD) of 13 grasses and 2 leguminous forages have been established. Maximum TDMD was found to be in 15 day old cuts of *C. ciliaris* presumably due to the high crude protein (CP) and low lignin contents. Due to the higher lignin content of the leguminous forages, their RDMD were found to be low. Amongst the grasses, *Tribulus elatus* followed the pattern of leguminous forages.

The desert sheep utilize the nitrogenous constituents of *C. ciliaris* more efficiently than those of *L. sindicus* under conditions of prolonged partial water deprivation. However, cellulose digestibility is generally higher in 50 per cent water restricted Marwari and Magra sheep compared to ad-lib watered animals. Dry matter digestibility of mature *Lasiurus sindicus* hay is of a low order in these breeds of sheep. Dry matter intake (DMI) of *P. cineraria* (*khejri*) leaves per unit body weight is significantly higher in the goat than in the sheep. In sheep, the digestibility of the cellulosic fraction of this feed was less than half that recorded for grass (*Cenchrus ciliaris*) cellulose.

ANIMAL PRODUCTION UNDER RANGE CONDITIONS

Water Requirements of Animals on Rangelands

The drinking water consumed per day by an adult dry cow weighing 272 kg increased from 19.3 litres in January to 41.1 litre in June; yearling heifers needed 10.2 to 17.0 litres; water consumed by an adult ewe increased from 2.1 to 4.5 litres and a ram lamb increased its water requirement from 1.6 to 4.0 litres during this period.

Stocking Rate in Range Areas

'Excellent', 'Good', 'Fair', 'Poor' and 'Very poor' conditions of rangelands (having approximate productivity of 20, 15, 10, 7.5 and 5.0 q/ha, respectively) can safely provide year-long grazing to 25.30, 20, 17, 13, and 1-6 adult cattle units per 100 hectare blocks respectively during normal years. In abnormal years, grazing stress has to be increased or decreased depending on the availability of forage on the rangelands.

Studies conducted on different stocking rates, without supplemental feeding, on different types of rangelands revealed that growth rate per animal remains the highest when the animals graze on the carrying capacity basis (2.40 ha/heifer). Although by increasing the stocking rate, viz., 1.20 and 0.60 q/heifer, the total livestock production goes up considerably, but the grass component, particulaly the annual species, gets eliminated through effective utilization. As a result, it has been considered necessary to provide concentrate feeds to the animals during the lean periods (December-June) to meet their digestible crude protein (DCP) and total digestible nutrients (TDN) requirements.

Goat vs Sheep Grazing

Studies on the comparative performance of goats and sheep on a sown pasture of Cenchrus species infested with *Zizyphus nummularia* and *Minosa hamata* bushes revealed 292 per cent increase in the body weight of male goat over that of ram lambs within a period of one year under light intensities of grazing (3 animals/ha). The increase in weight gain of the buck over the ram lamb was 178 and 75 per cent under medium (4 animals/ha) and heavy (6 animals/ha) intensities of grazing respectively.

Investigations on the goat's role in land use have shown the superiority of the desert goat to the sheep in several respects. The goat economises on water use. Its browsing habit not only provides it with a protein and mineral rich diet, but also does less harm to rangelands than does the close grazing habit of sheep. The goat can be reared in areas where cattle and sheep will fail to produce, or even survive. The goat is highly salt-tolerant, both in respect of feed and drinking water. By consuming salt-loaded shrubs, the goat is, in a way, reclaiming saline soils.

The general misconception regarding the goat's contribution to desertification needs to be removed. However, controlled grazing practice for the goat is a necessity. An efficient converter of scrub vegetation to meat and milk, the goat is indeed the 'Poor Man's Cow" which can if properly managed and improved, bridge the protein gap in the dietary of our people and earn a considerable amount of foreign exchange. The marginal lands of western Rajasthan provide the means to achieve this objective.

The Parbatsar Goat

A new breed of goat, the Parbatsar breed, has been established as a good dairy breed, well-adapted to desertic conditions. Its milk production performance can very well be compared with other good dairy breeds like the Jamnapari and Beetal.

ARID ZONE AGRICULTURE

The net area sown with crops annually in the whole of India, in Rajasthan and in desert districts of Rajasthan are almost similar, being about 45 per cent of the total land areas of the respective regions. In arid districts pulses contribute 25.6 per cent of the total food grain production and these districts contribute 1.7 per cent and 4.8 per cent respectively of India's total cereals and pulses production. 72.7 per cent bajra produced in Rajasthan comes from arid districts, which also make sizeable contribution to the production of oil seeds in the State.

Considerable work on agronomic practices influencing the yield of dryland crops, particularly, pearl millet has been done. Some of the important aspects on which research work has been carried out and technologies developed are as follows:–

Suitable Crops and Varieties

Suitable dryland crops and their varieties which match the rainfall pattern of the region and are efficient utilizers of rainfall and stored soil moisture have been identified. (Ex. bajra - BJ 104; mung S-8; moth T18; T-23; cowpeas FS 68; til T13; castor-aruna, GAUCH-1, bhaggya; sunflower-EC 68414; guar-durgapura saffed, FS-277, durgajai, HFG-75, 2470/12.)

Crops and varieties that have been found most suitable for late-sown conditions are: mung S-9, cowpeas K. 11, guar 2470/12, castor aruna, sunflower Ec 69874, EC 68414, moth T18.

Varieties of fodder crop having high-yield potential and well adapted to this area identified are : cowpeas HFC 42-1, moth T 3, guar 2470/12, guar JS 10, merta, bajra F-2 of BJ-104.

Contingent Crops

In view of very short available crop growing season particularly during droughts in arid zone, crops of minor millets were tried and improved. Among minor millets, a few varieties of kangni (*Setaria italica*) and chena (*Panicum miliaceum*) which have high-yield potential and can find place as a remunerative crop in the cropping system of arid zone have been identified.

Mid-Season Correction and Strategy to Meet Aberrant Weather Situations

A strategy to meet aberrant weather situations (early onset of monsoon, late onset of monsoon, early cessation of rains, drought at the seedling stage and drought at the flowering/grain filling stage, etc.) has been formulated and given a fair trial. Transplanting of bajra (21 to 25 days old seedlings) late in the season (end of July or begining of August) on a drizzling day, has been found to be the only way to obtain reasonably good yields of bajra. A fodder-cum-grain production system for early onset of monsoon; alternate crop and varieties, pre-sowing seed treatment, transplanting, early and complete weed control for late onset of monsoon; adjustment of plant population according to soil moisture availability, recycling of rain water harvested and stored in a pond earlier, ratooming, use of organic mulches for early cessation of monsoon; have been found to work well as contingency plans.

Cropping Systems for Drylands

Suitable and remunerative cropping systems, including intercropping systems have been identified. In good rainfall years (more than 500 mm) with an extended rainy season, it has been possible to follow a double crop system, viz., bajra (BJ 104) and mustard (T59) on drylands.

Inclusion of perennial grasses like *Cenchrus ciliaris,* castor bean, cluster bean, etc. in the cropping system have been found to impart stability to crop production. Intercropping systems, like *Cenchrus ciliaris* + guar (*C. ciliaris* + mung; sunflower + cowpeas/mung; mung (paired/triple rows) + bajra; castor bean + cowpeas (HFC-42-1); castor + moth (fodder); have been found to impart stability to production, besides being remunerative and efficient with regard to land (LER) and moisture utilization.

Crop Stand Establishment – Proper Tillage and Seedbed Preparation

Optimum plant population/density has been worked out for principal dryland crops (bajra, mung, guar, moth, til, etc). Techniques for securing proper and adequate crop stands have been evolved. Pre-sowing seed treatments (soaking of seeds in water) for hard coated seeds like sunflower, safflower and castor, have been standardized. Optimum seeding depth in respect of the above crops has also been worked out.

Sowing of seeds with seed drills having shovel type furrow openers and packing wheels proved more efficaceous for the situation in this region.

Preparation of seedbed with sweep cultivator was found to be expeditious and efficient with regard to weed control.

Gap filling 15 to 20 days after sowing with 21 to 25 days old seedlings of bajra proved useful in securing adequate plant stand in the event of heavy seedling mortality due to drought at seedling stage.

Soil Moisture Management/Water Harvesting

Procedures for harvesting water in situ through inter-row water harvesting and run-off concentration systems and collection of inevitable run-off in a pond have been standardized.

Crops and crop stages which benefit most by supplemental irrigation from the collected run-off have been identified.

Use of bentonite as a sub-surface moisture barrier has been found efficaceous in reducing losses of moisture in deep percolation in sandy soils. The technique of bentonite barrier coupled with run-off concentration system has been standardized.

Use of bajra husk as surface mulch has been found effective in reducing losses of moisture in evaporation, delaying surface drying and controlling surface crusting in bajra.

Run-off Farming

A technique for catching rain drops and cropping in run-off concentrated in level plot below the sealed catchment has been established. This technology has a good potential for increasing and stabilizing yields, lowering the risk of crop failure, saving the inputs of production, and making the best of every rain drop that falls on the farm. Among the various ratios of catchment of cultivated areas (viz. 0:5, 1:0 and 1:33), 0:5 ratio has appeared to be promising for crops like bajra, moong, guar, cowpea, til and sunflower. The apparent disadvantage of transfer of some areas for making catchment is sufficiently compensated by accumulated benefit over years. It has further been found that manipulation of inputs like seeds, fertilizer etc. in water harvesting system lead to increase crop yeilds.

Soil Fertility in Arid Areas of Rajasthan

The areas suffer from a general deficiency of nitrogen (0.02 to 0.07 per cent). The P_2O_5 content is high (0.05-1.0 per cent) but its availability is rather low. The available potassium is found in medium to high range.

In low rainfall areas, mitigation of nitrogen deficiency through fertilizer application in soil at sowing poses a problem as desirable effects are often not found in drought years and thus there is a possibility of investiment losses. However, split application – 30 kg N/ha at sowing and 15 kg N/ha one month after (as top dressing or foliar), if soil moisture is favourable, helps in bajra growth. It has again been found that even 80 kg N/ha may be applied to bajra through foliar application in four splits during its vegetative period with good results.

Effect of Micro-Nutrients

Soil application of Zn as $ZnSO_4$ has a significant and positive effect on the control of downy mildew in pearl millet (HB3). The effective level of Zn which depended on the severity of disease was 15 kg when the disease incidence was less than 45 per cent and 30 kg/ha when it was more. The incidence of disease had a negative correlation with Zn content in grain and a positive correlation with the P content of straw. Application of Zn increased the N-up take in pearl millet.

Techniques for Overcoming Problems Posed by Unfavourable Soil Physical Conditions

High intensity rain showers followed by rapid drying were found to form soil crust of high strength and thus affected the emergence of bajra and mustard seedlings. Ridge sowing, harrowing or sprinkling water after the formation of crust were found to mitigate the effects of soil crust formation and improve the emergence of seedlings.

Post sowing compaction of sandy soils with narrow iron wheel was found to increase the availability of moisture and thus improve the emergence of the seedlings of mustard and sunflower particularly under low moisture conditions of soil (5-6 per cent moisture).

Post emergence cultivation (one cultivation) of 5-10 cm depth done after one month of sowing resulted in improved physical conditions of soil, checked weed population, improved root growth and availability of nutrients and thus increased the production of pearl millet.

SALINE WATER USE FOR CROP PRODUCTION

Saline water of EC 9-12 mmhos can be used for continuous cropping instead of leaving the land fallow. Gypsum application (2 tons/ha) after harvest of rabi crop overcomes the detrimental effects of residual alkalinity after leaching of soluble salts thus making it suitable for the next crop.

UTILIZATION OF SOLAR ENERGY AND WIND POWER

As a result of research efforts to develop appropriate technology for utilization of solar energy for water heating, cooking, desalination, drying of agricultural produce, pumping water for irrigation, and wind power for pumping water and for generation of electricity, the following solar appliances for adoption in rural as well as urban areas have been developed:

1. Collector-cum-storage type of solar water heater
2. Solar water heater-cum-steam cooker
3. Solar water heater-cum-still
4. Solar cabinet dryer with autoregulation of temperature

Besides, investigations on the solar radiation regime over India from the point of view of solar energy utilization were carried out and design curves, based on normal solar radiation for 10 Indian stations, giving ratio of daily useful energy collection to heat removal efficiency factor vs temperature, have been prepared for typical summer and winter months.

A Simple Sail Wing Windmill

To utilize wind power potential for lifting water for irrigation from shallow water tables and for drinking purposes, a simple sail wing windmill costing Rs. 3,000 has been designed, developed and tested. The mechanism of the windmill is very simple and is autodirectional in operation.

RODENT PEST MANAGEMENT

Food of various rodent species and their pest status has been determined. Eight species, viz *Meriones hurrianae, Tatera indica, Rattus meltada, Gerbillus gleadowi, Funambulus, pennanti, Bandicota bengalensis, Rattus rattus* and *Mus musculus*, have been identified as most harmful to the crops and stored food grains in Rajasthan. Delineation of relatively abundant rodent species in western Rajasthan based on ecological distribution has been established as: up to 250 mm annual rainfall *G. gleadowi, M. hurrianae;* 250-400 mm *M. hurrianae, T. indica;* 400-500 mm *R. meltada, T. indica* canal irrigated crop *B. bengalensis, R. meltada.*

Investigations have revealed that large-scale operations should be taken up during May and June (population density and breeding rate of rodents being minimal during summer months) to minimize the operation cost and to maximize the efficacy. Bajra + 2 per cent groundnut oil is the most effective bait for mixing poison for rodent control. Pre-baiting should be carried out before poison baiting for 2-3 days to minimize the effect of neophobic behaviour of rodents. Two percent concentration of zinc phosphide has been found to be an equally effective dose for the control of rodents. The acute rodenticide (RH-787) and anticoagulants Brodifacoum and Chlorophacinone have been found effective for field rodent control. Control with zinc phosphide should be carried out only on a single day during one operation. This poison should be used again only after 3 months in the same area. If a repeat operation is needed, both bait and poison should be changed. The baits should be placed at a 10-15 m intervals for an optimal coverage of bait to all the rodents.

On the basis of ecological distribution of various rodent species in different habitats, soil and crop types, and considering their food, reproduction and population cycles, behavioural aspects and evaluation of a number of rodenticides, a number of strategies to control rodent population in field, residential premises and godowns have been standardized. A calendar of operation for farmers has also been formulated.

PLANT PROTECTION

The researches on plant protection measures have also received due attention. The methods for control of white grubs (*Helotricha sanguinea*) has received national recognition. The investigations revealed that application of 100 kg 10 per cent dust of BHC/ha or sevidol at 25 kg/ ha has given effective control. Use of fenitrothion 0.05 per cent a.i., dichlorovas 0.05 per cent a.i. and malathion 0.1 per cent in a three-spray schedule, the first beginning in mid October, the second three weeks later and the third six weeks after the second, have been successful for control of fruitfly in ber plants. Karathane o.2 per cent spray has been effective against powdery mildew in ber. Katra (*Amsacta*) larva a common pest in western Rajasthan has been effectively controlled by spraying crops with 0.025 per cent a.i. of quinalphos or methyl perathion. The incidence of bacterial blight (*Xanthomonas cyanopsidis*) of guar can be checked effectively when the seeds are treated with streptocycline at 0.025 g/kg. The dry root rot on cowpea caused by *Macrophomina* can be checked by treating seeds with 0.2 per cent bavistin.

SOCIO-ECONOMIC FACTORS AND NOMADISM

Nomads and Nomadism

An important social problem of the arid region is that of the nomads. Historical, political and cultural factors combined with climatic and geographical factors give rise to nomadic life. The nomadic groups of the arid zone may be broadly placed into four categories: (a) the pastoral nomads (Raikas, Sindhis, Parihars, Billochs, etc.); (b) the trading nomads (Banjaras, Ghattiwala, Jogis and Gowarias); (c) artisan nomads (the Gadoliya Lohars, Sansis and Sattias and (d) miscellaneous type of nomads (Nats, Kalbeliyas Jogis).

Detailed rehabilitation schemes have been prepared for the Banjaras (the trading nomads), the Gadoliya Lohars (the artisan nomads) and for the nomadic cattle breeders of the Anupgarh-Pungal region of Western Rajasthan, keeping in view their present cultural values, kinship structures and other important social and economic factors.

Impact of Drought on the Socio-Economic Structure of the Population

Intensive studies on the oral traditions, local evidences and empirical data pertaining to impact of drought have been undertaken in Nagaur and Jodhpur districts of western Rajasthan. The studies provide information on the traditional social indicators of drought prediction, perception of drought behaviour by the rural folk and socio-economic consequences of drought. The studies also provide empiricism to the various believed notions concerning the causes of drought, drought induced problems, social and economic disorders and bio-physical problems in nature etc.

Economic Evaluation of Arid Zone Technology

Cost-benefit analysis of sand dune stabilization fuel plantation, econo-ecological evaluation of xerophytic plant and tree species, fertilizer use in various crops and forage has been worked out. Economics of livestock was also worked out in relation to availability of feed and fodder in different areas of arid zone. The studies employing sophisticated techniques like project appraisal criteria, production functions, programming models have evaluated the economic viability of cropping, mixed farming, silva-pastoral and afforestation systems. This has added to the efficiency of facilities for extension of arid technology.

In addition to the above, several studies on various aspects of rural problems viz., empirical estimation of indicators of economic development, production performance of rural sector, marketing development and infrastructure, inputs supply system and production potentials, impact of dairy on land-use pattern and the state of economy of farmers, economic evaluation of different water-lifting devices and comparative economics of bullock and tractor power use in Uppler Luni Basin have also been conducted.

TRANSFER OF TECHNOLOGY

Operational Research Project

To transfer the technology to the field and to identify the gaps and constraints in the process of transfer two Operational Research Projects on 'Arid Land Management' and 'Drip and Sprinkler Irrigation Systems' have been undertaken near Jodhpur. The project on drip and sprinkler irrigation systems is aimed at enhancing the water use efficiency without impairing crop productivity. Under the 'Arid Land Management' programme, useful work has been done on sand dune stabilization, shelter belts and roadside plantation, grassland and horticulture development and crop production on drylands and under limited moisture supply conditions. The sprinkler system has been installed on 24 ha land belonging to six different farmers in the villages of Manaklao and Dahijar. In the rabi season of 1976-77 the system permitted recycling of ponded water on lands where other systems of irrigation could not be as effective. The technique of manufacturing drippers has been perfected in the Institute. More than 30,000 drippers have so far been manufactured in the workshop and installed on 0.6 ha of potato and 0.8 ha of citrus and pomegrante orchard in Dahijar village. Besides, a gobar gas plant has been installed to demonstrate the most efficient use of cattle dung for purposes of fuel as well as organic manure.

Lab to Land Programme

Under this programme 200 farming families belonging to the lower echelon of the rural society have been adopted for total development with 'family unit approach'. Demonstration of arid land technologies right in the fields of selected farmers, training both on-the-spot as well as at institute-level are being conducted to enlighten the farmers with different arid land technologies and to bridge the communication gap arising out of variations in income, land holding and social exposure. Seven villages have been selected from four western Rajasthan districts, namely Jodhpur, Bikaner, Pali and Jaisalmer, under this massive development programme.

Extension fortnight was conducted where farmers, youths, schoolboys, women folk participated and derived a good amount of inspiration from the Institute's scientists. Personnel from dairy development department, agricultural department and locust department also participated. It was a conglomeration of different departments at one point to benefit the farm community engaged in different persuits.

Farmers of Jaisalmer, Bikaner, Jodhpur have been enlightened with arid land technologies. Thus the awareness gap could be bridged to a considerable extent. Demonstrations conducted in the fields of farmers have sufficiently built up confidence among the farmers. However, lack of farm inputs, nearby markets and low investment capacity hinders the progress and thus multiplier effect is slow.

In kharif and rabi season the Institute organizes Farmers Day at Central Farm, Jodhpur, Bikaner and Pali, in which, farmers of the surrounding villages visit the experimental farm of the Institute and get acquainted with arid zone technologies through demonstrations, exhibitions and discussion with the scientists. Nearly 400-600 farmers participate in the field day.

On similar lines, field days are being organized by the division in the ORP areas to educate the farmers through demonstration. Nearly 50 farmers participate in the field day.

Extension leaflets in Hindi and English regarding the arid technologies and dry land farming are published from time to time and distributed to the farmers. Nearly 20 leaflets have been released so far for the benefit of the farmers. Besides this, farmers are intimated through rural radio broadcasts and press conferences from time to time.

Constraints in Technology Transference

In an analysis of different constraints limiting technology transfer it is observed that cost, non-availability of inputs in time and lack of irrigation facilities minimizing risk of crop failure are the major factors limiting use of hybrid seeds and commercial fertilizers. Besides "non-availability", "wrong availability" of inputs has equally setback the transfer of technology in certain cases. To cite an example, supply of mixed seeds in place of hybried bajra in one year followed by severe ergot infection put back the hybrid seed programme and it needed much effort to re-establish farmers' faith in the programme. Nearly half of the farmers still believe that use of fertilizers deteriorates soil fertility. Regarding use of pesticides, cost and poor knowledge about their use were the dominant factors, but few farmers did not feel the need for pesticides use.

Farmers' general beliefs that mixed cropping (bajra + moong + moth + til) covers the risk of crop failure, that grains of local bajra and wheat are sweeter in taste, that fertilizer spoils land and deteriorates grain quality, that crop remains thirsty if irrigated by method other than flooding, that pesticides poison the grain, that use of fertilizers make land surface white (saline) etc. are no doubt slowly dying out but are still a factor limiting faster technology transfer.

GAPS IN KNOWLEDGE

The foregoing pages outlined the main results and status of research in the arid zone conducted by CAZRI, not only to reclaim the desert but also to ameliorate the desertic conditions. Discipline-wise, technical bulletins have been published in a few cases by individual scientists. Thus on the basis of the scientific knowledge gained and the technology developed, the Great Indian Desert can claim to be one of the best studied deserts of the world and for which CAZRI is a large data base. But it will be appropriate that the voluminous data generated be critically examined and synthesised for preparation of a master plan or blueprint for local and area specific development.

However, looking to the vast dimensions of the problem, investigations on the following aspects, to enumerate a few, need to be intensified:

- Devising crop-water-soil management practices condusive to the build up of soil fertility and to improve the soil physical conditions, so as to obtain maximum crop output per unit water.

- Identification of non-monetary inputs and their impact on crop production.

- Diverse and graded technology for small, marginal and medium sized farmers depending upon socio-economic conditions and requirements.

- Under rain-fed situations the desirable density of vegetation (grass, trees and crops) has to be ascertained in reckoning with moisture availability and other conditions.

- Studies on agro-forestry, silvi-pastoral, and horti-pastoral systems need intensification.

- Quantification of available water potential (water balance) of individual water sheds is necessary.

- For precise assessment of total ground water resources and timely prevention of overdraft of water resources, hydrological investigations need intensification on mini-water-shed or index catchment basis.

- The processes and problems occuring due to advent of canal irrigation, like rise of water table, salinity, seepage losses, etc. need to be studied in depth.

- Research on wind erosion control needs intensification in relation to type of sand dune, direction of wind and control of hazards like removal of soil and nutrients under different land use conditions and to develop new technologies for cultivation on marginal lands.

- Intensive research is needed on the genetics and breedings of trees, shrubs (especially indegenous) forage grasses, and legumes for obtaining desirable attributes.

- Identification of new alternate sources of plant products of industrial importance in arid zone in respect of medicinal, essential oil and insecticidal value.

- There is a severe paucity of improved grass seeds for regenerating the existing pasture and rangelands. Moreover, intensive large scale grassland improvement programmes are envisaged to enhance the productivity of the arid lands. Therefore, there is an urgent need for establishing the grass seed farms to meet the requirements of grassland improvement and development programmes.

- Inspite of the useful contribution made by CAZRI's research efforts, the diffusion and adoption of the scientific knowledge gained and technologies developed have not made breakthrough on the development front. Therefore, major emphasis needs to be placed on 'Extension and Communication Research' in which the constraints with adoption of technologies in the areas already saturated with extension service may be analysed in more detail and consequent remedies found for effective implementation.

- As the ultimate success of programmes will largely depend on the extent of involvement of the desert people, emphasis needs to be given to training and education of farmers and extension works. Regular short duration training courses are necessary for farmers as well as village-level agencies such as VLW, agricultural overseers, BDOs and other agricultural extension officers, which will act as refresher courses and make them acquainted with innovations and recent research findings from time to time.

- Studies have shown an existence of nearly 3 million ha of salt affected soils in the region. Over the years a technology based on leaching with canal waters and use of amendments has been developed. However, for much of the problematic area, such sources of fresh water are not available. Recent work suggests that some improvement should be possible with soil working and use of amendments only. More studies need to be undertaken in this regard.

INDONESIA

Combat Against Desertification in Nusa Tenggara Timur, a Semi - Arid Region in Indonesia

by

H. Ataupah*

Summary

Compared with most of the lush tropical islands of Indonesia, the chain of islands stretching eastward from Bali up to the small Malukuan islands at the eastern tip of Timor, has a semi-arid condition. This condition is caused by the complex interactions of physical features, uncertain weather conditions, and human actions. But the condition is not a homogenous one.

This report is primarily concentrated on Nusa Tenggara Timur, the central part of the arid-region. There are 1.9 million ha of critical lands in Nusa Tenggara Timur, out of the 18 million ha of critical lands in Indonesia. That is why reforestation and regreening programmes in Nusa Tenggara Timur are carried out simultanously with those programmes in the humid islands of Indonesia.

Much progress has been made, but traditional hampering factors such as physical features, weather conditions, fires, straying cattle, and socio-economic values are still present.

To put reforestation and regreening programmes at a maximum success, various improvements are initiated in public administration, development administration, organization, planning and monitoring systems.

Centres for Environmental Studies were established in 1979 to carry out various environmental studies to support the national development plan, including the anti-desertification programmes in Indonesia. One of these centres is established at the Nusa Cendana University. It is conducting a study to ascertain in detail the local varying conditions of the eco-systems of the semi-arid region, especially Nusa Tenggara Timur.

Nusa Tenggara Timur has received increased attention from the Central Government. Routine budgets of reforestation and regreening programmes have been increased considerably within recent fiscal years. Extra funds are allocated to foster and push forward the regreening programmes on seriously degrading watersheds. The involvement of local villagers in regreening programmes is activated through various intensified information channels. The presence of the President of Indonesia at the opening ceremony of the 19th anniversary of the of National Regreening Week, in the vicinity of Kupang at the end of 1979, (the second time for such a national occasion within five years) was of great importance to the anti-desertification programmes. The presence of the President is technically followed by various actions of the Government and the inhabitants of Nusa Tenggara Timur.

Industrial development is at its infancy and urbanization is due to the concentration of high school facilities in urban centres. Consequently there are no combined negative effects of industrialization and urbanization in Nusa Tenggara Timur. The main source of ecologioal problems is the combined effects of swidden agriculture, traditional cattle raising, and fire outburstings, on the dry natural environment.

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There are no new significant corrective anti-desertification measures in Indonesia.

There are no specific insurances against the risk and effects of drought in Nusa Tenggara Timur or any other part of Indonesia. If any food crop failure occurs, the Logistic Depot in Kupang is charged to solve the food shortages to overcome further complications.

Introduction

Unlike the other lush tropical islands in Indonesia, the chain of islands stretching eastward from Bali up to small Malukuan islands at the eastern tip of Timur, has a semi-arid condition. This condition is caused by the interactions of natural physical features, climate and human actions.

This report is primarily concentrated on the Nusa Tenggara Islands, the central part of the arid-region. There are at least 1.9 million ha of critical lands in this region, out of the estimated 18 million ha of critical lands in Indonesia. That is why reforestation and regreening programmes which are now being carried out in Nusa Tenggara Timur must be considered as integrated programme of the national campaign against critical lands all over Indonesia. Within the framework of the pattern, strategy, priority, and policy of the National Development Plan in Indonesia, the Province Combat of Nusa Tenggara Timur is simultaneously developed with that of the other Provinces in Indonesia. The destruction of productive land, water, forests, and other natural resources has taken place in both the densely and sparsely populated islands. In other words, desertification is happening also in the humid islands in Indonesia. Although the final physical outcome of desertification in humid islands will be a different one to that in semi-arid or arid lands, the socio-economic problems are the same.

Since the semi-arid conditions in Nusa Tenggara Timur reported here are scattered in many areas with varying situations, this report contains much information which must be treated specifically when to fully understand the combat of desertification in Nusa Tenggara Timur.

EVALUATION OF DESERTIFICATION AND IMPROVEMENT OF LAND MANAGEMENT IN NUSA TENGGARA TIMUR

Background Information.

Nusa Tenggara Timur is located between the meridians of 118°55'-125°1' E.L., and 8°3'-11°2' S.L. It consists of 111 islands with a total land area of 48,900 sq.km. and sea area of 96,000 sq.km.

Contemporary geologists divide this archipelago into two groups, the Inner Arc Islands and the Outer Arc Islands. The Inner Islands are mostly of volcanic origin (except some areas in East Flores and East Alor, which are of calcareous limestone origin), which are rich and productive basically. They consist of Flores and the surrounding islands, Solor, Adonara, Lembata or Lomblen, Pantar, and Alor and its surrounding islets.

The Outer Arc Islands are mostly of calcareous limestone origin with old volcanic materials at the northern coast of Timur, which are relatively less rich and productive compared with the soils of the Inner Arc Islands.

Compared with the other lush tropical islands in Indonesia, the Nusa Tenggara Islands have a semi-arid condition. This condition is not a homogeneous one all over the archipelago. There are varying and gradual differences of local conditions which are caused by the complex interactions of natural physical environment, climate, and human actions over many centuries.

Volcanic activities as well as geological processes such as folding, faulting, emerging, submerging and so on, caused complicated reliefs which are broadly characterized by cores of rugged hills and mountains, highly dissected ridges trending to various directions and craggy mountain uplands with varying elevations, sometimes higher than 2,000 m above sea level.

These physical features play an important and influential role in conditioning weather elements in the region, which in turn influence the vegetation cover, water availability, eroding processes, human adjustment and so on.

During rainy seasons, the W-NW monsoon wind loses a lot of its raindrops in West Indonesia and North Indonesia before it reaches the rugged hills and mountains of Nusa Tenggara Timur. The rainfall becomes relatively less in Nusa Tenggara Timur because of its more southerly position and rugged physical features. Furthermore, the beginning, duration, ending, and distribution become uncertain. The northern hills and mountains, as well as coastal areas, receive earlier rainfall in November, while the southern hills and mountains as well as coastal areas sometimes get the first rainfall late in December with uncertain heaviness. During dry season the E-SE wind, originating in Australia and blowing over relative a narrow sea, contains less raindrops compared with the W-NW monsoon wind and most of its raindrops are lost on the narrow coastal hills and lowlands, so that usually the northern hills remain relatively untouched by rainfall. The up to 26 knots E-SE winds are desiccating the calcareous limestone islands of Timur, Sumba and East Flores so that the soils of the areas become strakly dry during the rainless dry seasons. Since the rainfall varies from unexpected showers of more than 450 mm within 24 hours to 450 mm within a year, the drying E-SE winds can cause much damage and numerous disasters such as the drying up of rivers, springs, wells, the burning of grasslands and srubs, with their consequent human sufferings. Damages and disasters have their specific cumulative nature when the foregoing rainy season of the same year or consecutive years, has or have too little rainfall or too much rainfall accompanied by fast-blowing N-NW winds which cause floods, land-slidings, failures of foodcrops, and so on.

Each of the other weather elements (temperature, humidity, cloudness, sunshine and radiation, evaporation, and atmospheric pressure) plays its own specific role toward a semi-arid climate in Nusa Tenggara Timur.

Land Management and Desertification.

Simple and traditional human beings have been adjusting themselves conspiciously to their environment for centuries. The remarkable phenomenon is that they depend upon their environment to sustain their lives and future, but they do not take sufficient actions to preserve the carrying capacity of their environment. They are unaware of their deteriorating environment caused by their actions. At the present stage of development, the land management and desertification should be briefly discussed as follows:

a. Swidden Agriculture and Extensive Livestock Keeping.

With an annual average increase of 1.69 per cent, more than 80 per cent of the 2.5 million inhabitants of Nusa Tenggara Timur are swidden agriculturists. In reality, they are not pure swidden agriculturists, because whenever it is possible they are performing other extensive traditional activities such as hunting, gathering forestry products, keeping livestocks, and so on. By performing various activities they minimize or shift risks in a traditonal manner.

Fallowing croplands when the harvest is decreasing is a common traditional practice in swidden agriculture. But since the number of swidden agriculturists is increasing, the fallowing period must be theoretically shorter, compared with the fallowing periods in former times. But as soon as the cultivated lands are abandoned for natural restoration, straying cattle and other grazing animals pour into these lands. Remnants of food crops, grasses, young trees, shoots, and other palatable vegetation are cleared thoroughly by these hungry animals within a short period of time. The fallowed lands are denuded, and become easily eroded, and the fallowing period is forced to be prolonged. If the swidden agriculturist cannot find a better patch of land to plant his food crops he arbitrarily goes to the protected forest areas, or is forced by the situation to go back to his less productive fallowed land which has been devastated by animals. *Leucaena glauca* trees, *Sesbania grandiflora,* and other trees planted by the swidden agriculturists within the framework of the National Regreening Movement (Gerakan Penghijauan Nasional) are sometimes also destroyed by straying animals.

To get rid of this situation the Government is persuading the people, especially the villagers to have their grazing animals fastened and stabled periodically, or to plant various palatable tree species to provide green fodder for their livestock. It will take some more time before this improving action reaches a satisfactory level. The traditional attitude of letting straying livestocks look for their own fodder and water is still deeply rooted in the hearts of cattle owners as well as the swidden agriculturists. When horses and Bali cattle were imported in the 19th and 20th centuries to bolster the region's economy, this traditional attitude was maintained. Officially there were 1,052,950 grazing animals (400,811 Bali cattle, 123,475 water buffaloes, 183,618 ponies and horses, 291,372 goats, 53,679 sheep) in Nusa Tenggara Timur at the beginning of 1980. Besides that number of grazers there are 691,065 pigs, which are also straying animals in many cases.

Swidden agriculturists and straying animals are the main cause of the process of desertification in Nusa Tenggara Timur. But the swidden agriculturists do not initiate any significant action to change the situation. They do not fertilize lands, like the wet rice cultivators, nor do something else which may be considered as better land management.

b. Fire, Firewood, and Fences.

Fire is used as a traditional tool by the inhabitants of Nusa Tenggara Timur. It is used by hunters, forest product gatherers, swidden agriculturists, and cattle raisers. The immediate objective of using fire is understood by everyone, but the environmental deterioration caused by the use of fire is not yet fully understood by the common people. Fire is easily made and used by everyone, while the drying grasses and the fast blowing winds in the dry season, facilitate the use of fire as a tool. The outbursts of fire in grasslands and protected forests occur frequently. Sometimes newly reforested as well as newly regreened lands are devastated by fire originating from the fields of swidden agriculturists or from any careless person. Many measures are taken to prevent fire outbursts but as long as fire is used as a tool in the agricultural activities in Nusa Tenggara Timur, the menace of desertification is here to stay. There are no available statistical figures about losses caused by fire outbursts, but there is much self-clarifying evidence that the damage is great.

Firewood is used in kitchens for cooking and boiling activities, as well as for heating purposes during the cool nights and mornings in mountain areas. At least three pieces of large firewood are used at once to keep the fire going day and night to ensure sufficient heat and light in traditional houses. Statiscal figures are not available at the present time, but if it is assumed that at least 100,000 traditional houses are lighted and heated by the above mentioned traditional manner all year round, a lot of firewood is consumed for that purpose.

Firewood is also used by peasants to guard their crops against animal attacks at night, especially when wooden fences have not been erected. A large amount of dry wood is burnt when peasants are forced to erect fences at night to protect their newly planted crops from straying pigs, cattle, and Wild animals. Much more firewood is consumed at the guarding time before harvesting to chase animals away.

Strong wooden fences must be erected to prevent livestock and wild animals from devastating food crops, villages, reforested and regreened lands. Since many branches within the newly cultivated lands are burnt out during the clearing period or are consumed as firewood, the wood for fences must be taken from the nearby forests and bushes. This action helps to deplete the forests and bushes of which there is now a minimum quantity.

The fences will be in effective use for two to four years, depending on the kinds of wood used. After this effective period, the fences are left to rot, or are burnt out, or are used as firewood when the cropland is abandoned. When the land is still in use, the wood must be replaced or a new fence must be erected.

Many reforested and regreened lands are denuded again by grazers, after the protecting fences are broken, rotten, or burnt. Barriers made of stones have a lasting duration, but it takes more time, effort and skill to build such barriers. Many villagers do not build them although suitable corral stones are available in many places. Barbed wire is too expensive for common villagers.

c. *Regreening and Reforestation.*

The process of environmental deterioration have been taking place for many generations. Intermittent and incidental actions were taken by many local leaders and villagers to prevent serious deterioration in many places in Nusa Tenggara Timur.

In the 1930's, the *Leueaena glauca* was introduced and planted side by side with the *Sebania glandifora* which was introduced ealier. Soon it become evident, that the *Leucaena glauca* has a superior capacity as a natural fertilizer, a standing green fodder and as an instrument to prevent erosion. This tree is welcomed by villagers.

Since the introduction of the National Regreening Week (Pekan Penghijauan Nasional) in 1961, the Leucaena glauca has been extensively planted throughout Nusa Tenggara Timur by the Government as well as by villagers.

Despite all the vigorously carried out programmes of reforestation, afforestation and regreening which have been supported by villagers, churches, private organizations until the end of 1973, there were still 512,400 ha of critical lands within the protected areas, and 1,509,000 ha outside the protected forest areas. Thus the total critical lands in Nusa Tenggara Timur at that time was 2,012,400 ha. At the end of 1977 the remaining critical lands within the protected forest areas was 504,600 ha, and outside the protected forest areas was 1,497,178 ha. The total remaining critical lands was 2,001,778 ha out of the total national figure of approximately 18 million ha.

After the Nairobi Conference in 1977, the annual reforestation and regreening programmes were at a constant rate, as follow:

	1978	1979
Reforestation	5,390 ha	5,380 ha
Regreening	13,900 ha	13,900 ha

Further information about the reforestation and regreening programmes in 1979 is as follow:

1. Through a routine budget of the Presidential Instruction on Reforestation and Regreening, Nusa Tenggara Timur receives a total fund of Rp 1,012,893,000 (equivalent to $US 1,602,636. 80 at the official rate of exchange, Rp 625 = $US1.) which is divided into Rp. 447,661,000 for regreening programmes and Rp. 565,232,000 for reforestation programmes.

The Rp 447,661,000 budget is allocated to finance the planting of 13,590 ha of critical lands, the contour terracing of 710 ha, the caring of 16,564 ha of lands planted within the last two years, the building of two check dams and the buying of 9,602,500 seedlings.

The budget of Rp 565,232,000 is allocated to finance the planting of 5,380 ha of critical lands, the caring of 7,965 ha of lands planted within the last two years, the building of 10 km of forest road, the clearing of 362.5 km of fire-breaking spaces, the buying of 53,882,000 seedlings, the nursing of 3,332,000 seedlings and the buying of 16,100 kgs of seeds.

2. Besides the above mentioned routine budget, the President of Indonesia has allocated an extra regreening budget of Rp 500 million for contour terracing at the Noemina watershed in Timur, the Aisesa watershed in Flores, and the Mangili watershed in Sumba. This extra budget is intended to supplement the regreening programmes initiated by local villagers and local government.

3. The President of Indonesia and members of his Cabinet attended the opening ceremony of the 19th anniversary of the National Regreening Week at the village of Besmarak in the vicinity of

Kupang, the capital of Nusa Tenggara Timur on December 17, 1979. It was for the second time that Timur was selected as the site of the opening ceremony of the National Regreening Week. The first time was in December 17, 1974. It is a custom in Indonesia that the opening ceremony of the National Regreening Week takes place at well-chosen sites to promote the national campaign against critical lands.

The Provinces of West Java, Central Java, Jogyakarta, East Java, Lampung, South Sumatra, North Sumatera, South Sulawesi, Central Sulawesi, North Sulawesi, South Kalimantan, West Kalimantan have had their turn too.

THE COMBINATION OF INDUSTRIALIZATION AND URBANIZATION WITH THE DEVELOPMENT OF AGRICULTURE AND THEIR EFFECTS ON ECOLOGY IN NUSA TENGGARA TIMUR

At the present stage of development there are no combined negative effects between industrialization and urbanization upon agriculture. Consequently there are no further combined negative effects between industrialization, urbanization and the development of agriculture on ecology in Nusa Tenggara Timur. Each sector, however, has some negative effects on ecology which are briefly discussed below.

1. Industrialization.

The development of a viable manufacturing industry in Nusa Tenggara Timur is at its infancy. Nearly all industrial goods are imported from other parts of Indonesia or from abroad. There are only some rice milling, coffee milling, saw milling, coconut oil processing, sandalwood oil distilling, leather tanning which have relatively minor effects on the immediate surroundings of the manufacturing firms.

2. Urbanization.

Out of the more than 2.5 million inhabitants of Nusa Tenggara Timur in 1980, 90,000 are living in Kupang, the capital of Nusa Tenggara Timur (and the Kabupaten Kupang). The population of Kupang has increased from 54,000 in 1960 to 90,000 in 1980, but the increase is due to the growing number of Junior and Senior High School students and students at the Nusa Cendana University. The number of civil servants is also increasing because governmental activities have soared in this decade of development (1970-1980). Hills at the southern side of Kupang are denuded for firewood, especially by the High School students who come from simple families in the hinterland of Timur. Capital of the 11 Kabupaten of the Province of Nusa Tenggara Timur which are considered as the major urban centres in Nusa Tenggara Timur are experiencing the same phenomenon as Kupang. The total increase in population of the 11 urban centres and Kupang itself from 1975 to 1980 is 57,384 (from 216,476 to 273,860). The total increase of employees in manufacturing firms is 371 (from 8,328 to 8,699).

3. The Development of Agriculture.

The inhabitants of Nusa Tenggara Timur did not realize that they had a low standard of living during the colonial period. The colonial authorities let Nusa Tenggara Timur become a backwater of their empire. They were successful in putting an end to tribal wars and exterminating contaminating epidemics among the native people, but they did not do much to raise the standard of living of this people. To bolster the region's economy, the Dutch authorities and their Chinese middlemen imported cattle at the beginning of this century. Through mis-management, the natural savanas and grasslands in Nusa Tenggara Timur especially in Timur and Sumba were devastated, but the elite of the traditional society, through whom cattle were distributed, prospered somewhat. After national independence the swidden agriculturists expanded their dryland-croplands to catch up with their traditional leaders. They also began to raise cattle extensively. As a result, there is a combination of swidden agricultural practices and extensive cattle raising which hastens the degradation of the dry calcareous limestone soils.

CORRECTIVE ANTI-DESERTIFICATION MEASURES

Indonesia does not take any significant anti-desertification measure at the operational level. But the country has improved its management capacity in dealing with reforestation and regreening programmes.

The systems of planning and monitoring have been improved considerably. At first the Directorate General of Forestry which is in the Department of Agriculture was in charge of monitoring activities in reforestation and regreening. When it became evident that there were many problems in regreening which originated from land ownership and land status, the monitoring of regreening programmes was put under the Directorate General of Agraria in the Department of Interior. The Directorate General of Forestry is still in charge of the monitoring of reforestation programmes.

Seriously degrading watersheds are surveyed and integratedly developed, these include watersheds in Flores, Timur, and Sumba. The cause of failures are studied more carefully to avoid future failures.

It has been discovered through carefull evaluations of the reforestation and regreening programmes of 1978/1979 and 1979/1980 in Nusa Tenggara Timur that:

1. The co-ordination of all concerned with the reforestation and regreening programmes is of major importance to the success of the team-work. The flow of documents, information and funds has an indirect but vital consequence on the timing of planting of seedlings and seeds which in turn determines the fate of growth of young trees on dry soils.

2. Straying cattle are destructive to reforestation and regreening. Drastic action to restrict straying animals is badly needed.

3. Weeding is needed to distract hungry cattle and to avoid fire but, on the other hand, there is the problem of over-evaporation.

SOCIO-ECONOMIC ASPECTS

There are many socio-economic problems which have to be solved to put reforestation and regreening programmes at a desired degree of success. But in this report three problems which constitute the major difficulties faced in Nusa Tenggara Timur will be put forward.

1. The Effects of the Traditional Dispersed Pattern of Settlements

Nobody knows exactly, how and when the ancestors of the present population of Nusa Teng gara Timur settled in the islands. But there might have been waves of migrating Negritoes, Melanesians, Polynesians, Proto-Malays and Neo-Malays who used the islands as stepping stones to other parts of the world, or made them their permanent homeland.

Tribal competition, conflicts, wars, treaties, inter-marriage contacts with newcomers, gradual adjustments to the physical features and many other factors produced the present population with their diversified characteristics but not necessarily conflicting values.

Based on socio-economic and security considerations, traditional settlements were created on hilltops, steep slopes and in inaccessable valleys. Some of these traditional settlements were deserted when the tribal wars were ended or when the government decided to resettle the people from such isolated villagers. Many settlements of this kind are still in existance. Physically the former isolated settlements were deserted or going to be evacuated. But historical events, which might be of great importance to the villagers, are deeply rooted in the hearts of these people. By tradition they claim the forest territory as their homeland and mentally avoid the idea of resettlement in the lowlands which they consider belong to other groups. They are stacking on the heavily eroded slopes with some trees

Within the economic development plan, agricultural development is given high priority, supported by miscellaneous plans to achieve a long-run equilibrium, where the agricultural sectors will be supported by a strong system of industry. A development administration is being formed to manage the complex plan. Public administration is geared to the development process in such a way that the Governor becomes the single development administrator, single Public/Government administrator, and the single Community administrator in every province. The governor is accountable to the President of Indonesia via the Minister of Interior. Within the framework of the national development administration in Indonesia, all development activities in Nusa Tenggara Timur are planned by the Regional Development Board (Bappeda), assisted technically by the Head of Provincial Dinases, and the agencies of the Central Government at the Provincial level. In this way, overlappings, discrepancies and any other shortcomings are avoided as far as possible.

Since reforestation and regreening programmes are directly related to the fate of the people, the President of Indonesia has given Presidential Instructions for Reforestation and regreening to be carried out from the national to the village level. The Minister of Agriculture, the Minister of Finance, the Minister of Interior Affairs, the Governor, the Bupati, the Camat, Head of Village, land owners, daily loan earners, any many other officials concerned, are given stipulated instructions to carry out reforestation and regreening, technically, administratively and socially.

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IRAN

Desert and Desertification Control in Iran

by

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Introduction

Soil erosion in Iran is as old as agriculture itself. Geological and climatological factors along with intensive land use by man for more than five thousand years have resulted in the appearance of all kinds of erosion and soil depletion in Iran.

During all that time most of the luxuriant forests of the Caspian Zone have been destroyed by man to provide more lands for agricultural purposes or as a result of faulty wood utilization. The natural forests of Halozylon and Tamarix that once covered a large part of the present deserts were cut for fuel or other uses. Over-grazing by millions of goats and sheep have depleted most range-lands of Iran.

Physiography of Iran

Total land area of Iran is 165 million hectares. It is the second largest country in the Middle East, and extends from latitude 26° to 38° north and from longtitude 44° to 63° east. Because of this wide range in latitude and longtitude, Iran is also one of the most variable countries from the standpoint of physiography, climate and vegetation.

Four main physiographic provinces are distinguished in Iran (Dewan and Famouri, 1964) which are as follows:

1) The Elburz and Zagros Mountain ranges and the extensions.
2) The Caspian Sea Coast.
3) The Khuzistan and Southern Coastal Plains.
4) The Central Plateau.

The Elburz and Zagros Moutain Province

The Elburz Mountains, running almost due east and west, form a continuous range across northern Iran. The Zagros Mountains extend along the western border of the country. Their extensions, the Mokran Mountains, continue along the southern coast to the Gulf of Oman. Thus this physiographic province lies as an inverted "V" which encircles the Central Plateau and profoundly affects the climate and development of the whole country.

The generally rough topography and thin soils in this province combine to discourage settlement, especially in the south, where high temperatures and low rainfall limit the vegetation and the mountains are mostly barren. The most characteristic vegetation over much of the province consists of scrub forests of oak, juniper and other species, most of which have been severely cut over the centuries for fuel or charcoal. However, in the north, more productive commercial forests exist, and the higher mountain valleys provide some areas for cultivation or summer grazing grounds.

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Here again wind is a common feature of the environment. This is particularly true near the mountains where strong, sustained winds occur. It is in this climatic zone that the most extensive dune fields are located.

Sand Dune Stabilization in Iran

Dune fields are also common wherever faulty land utilization has continued until vegetative cover and soil structure have been destroyed. In the past the eventual result has been abandonment of land. This is a universal feature of historically old culture. The cycle of settlement, development, over utilization, dune information and abandonment has been repeated many times in Iran. The existing dune fields can in many instances be related to past civilizations.

Because this report is concerned with the problems which are associated to arid and semi-arid regions, desert and desertification control will be described in greater detail.

Of those four physiographic provinces that have been mentioned, the Central Plateau and the Khuzistan and southern coastal plains embrace the major arid and semi-arid regions of Iran.

Of Iran's total land area of 165 million hectares, true desert occupies about one-fourth (about 40 million hectares), of which 5 million hectares are active dunes in a vast area in the south-west and south-east. The majority are continental dunes, but maritime dunes are also to be found along the southern coast line of Iran and for some distance inland. Table 1 presents a tabulation of dune fields as identified by Dewan and Famouri in 1961.

Table 1 : Distribution of Coastal and Inland Dune Fields in Iran (in 1000 ha.)

Province	Coastal & Interior Dunes	Desert soils with Dunes	Seirozoms & Regosols	Total Area
Gilan	–	–	–	–
Mazandaran	360	–	260	620
Azarbaijan				
East & West	–	–	–	–
Khurdistan	–	–	–	–
Kermanshah	–	–	–	–
Khuzistan	240	–	–	240
Fars	40	–	640	680
Kerman	440	1,560	1,680	3,680
Khorassan	400	–	4,500	4,900
Isfahan	640	3,770	1,600	6,010
Baluchistan	920	640	520	2,080
Tehran	–	–	80	90

Data from 1961

The area which is occupied by moving dunes, along with wind action, creates the following problems for this country:

1) Pollution of the aerial environment of cities and villages.
2) Abandonment of villages and cultivated lands.

3) Obstruction of highways, railroads, airports, oil wells and industrial establishments, and destruction of communication facilities.

4) Deterioration of rangelands and agricultural lands.

5) Destruction of water systems by filling the irrigation canals.

Aridity of the Plateau is characteristic with summers being temperate to hot and dry. Winter climate is determined by precipitation which is limited and erratic. Annual precipitation which is related to elevation, varies from about 100 mm to over 600 mm.

Here again wind is a common feature of the environment. This is particularly true near the mountains where strong, sustained winds occur. It is in this climatic zone that the most extensive dune fields are located.

The Sand Dune Stabilization Project

During the last two decades, damage associated with sand movement and dune encroachment was increasing annually. Villages by the hundreds were being abandoned because they were actually being buried by sand. Fields were not planted because they would be buried beneath sand before the crop was ready to harvest. Newspapers frequently carried stories of trains being derailed, about airports being closed and mosques being buried. Air poilution was accepted as a natural characteristic of the affected regions. Life was generally miserable.

Awareness of the increasing severity of sand encroachment developed in about 1958 when it was recognized that sand damage had occurred since 1945. At this time two small demonstratons to test mechanical methods of controlling sand drift were established about 30 km north of Ahwaz. Although these demonstrations were successful, no further activity was initiated until late 1965 and 1966, when Iranian experts returned from study tours in Russia and Pakistan.

The first truly serious effort to check the encroachment of dune fields was initiated in 1965 on 100 ha adjacent to the village of Haresabad near the city of Sabzevar and on two 10 ha plots near Ahwaz. (Fig. II)

Haresabad was already partially buried by dunes that had a maximum height of 6 m. The villagers had given up hope of saving their village and jeered technicians who had come from the city to save their settlement. The scheme, to the villagers was another grandiose government undertaking that was doomed to failure.

Fortunately, the efforts were successful. Native species such as *Ferula Galvanifera* and *Aristida Pinnata* were used to construct palisades. *Haloxylon Persicum* transplanted from nurseries to the dune fields quickly established. In three years, a young forest with trees up to 3 m. tall had become established. The wind was lifted away from the soil surface. The sand ceased to roll into the village. Now the villagers, secure in their homes, were again able to till their fields.

The work at Sabsevar demonstrated that dune stabilization was a feasible operation. Consequently, support for this project was increased. Today the project is operating more than 60 substations in 11 Ostans[1] which are shown in Fig. II.

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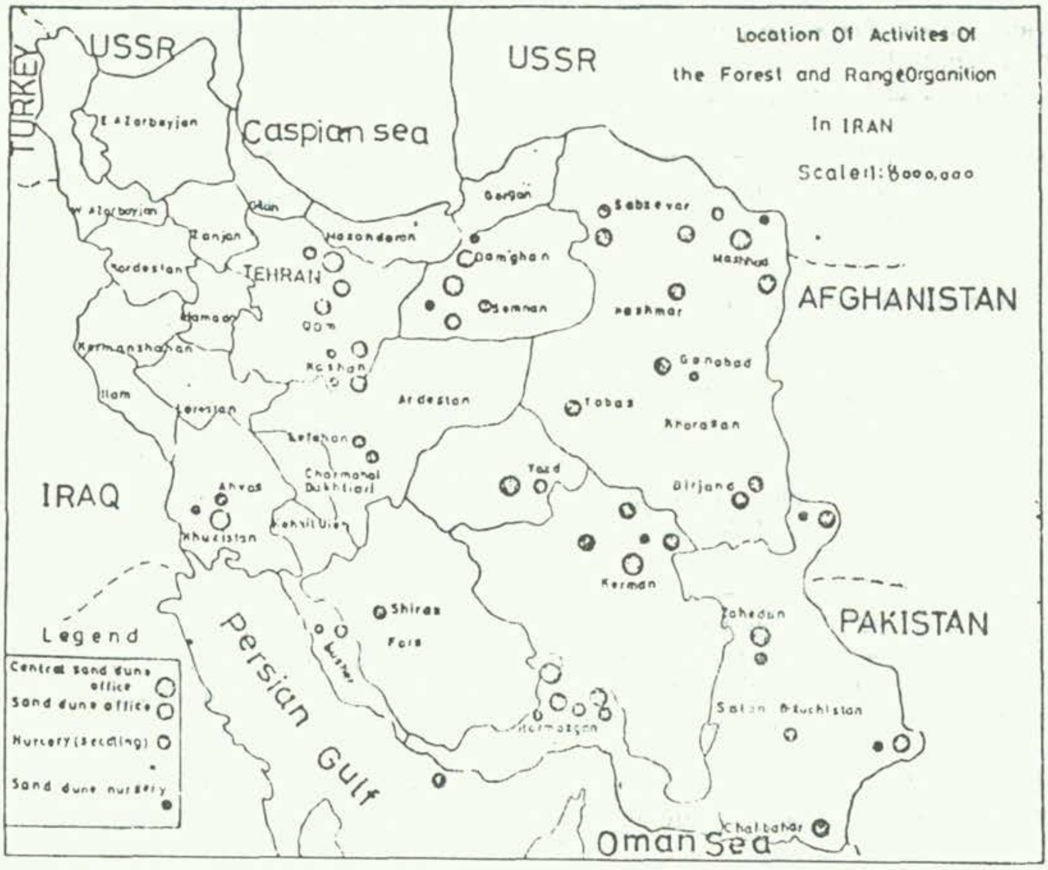
[1] Equivalent to state.

Fig. II



Procedures and Methods

Because the project was initially conceived as an emergency measure with the primary objective of saving and protecting villages, mosques, communication systems, project activities were concentrated on the most critical areas. Until 1974 attention was concentrated on protection rather than production.

In nearly every sub-project, the first activity was to develop a nursery in which planting stock could be produced. Living quarters, wells, deisel powered pump and irrigation systems were established at these nurseries.

Planting stock of many woody and several grass species has been produced (Table 2). Woody species are planted in plastic bags or in beds. Grasses are planted in beds. The planting schedule is such that woody species are three to six months old and 20-30 cm tall at the time when field planting should be done. Woody species are transplanted in plastic bags or as bare-root plants. Grass species are planted as sprigs that are produced in the nursery or are obtained from plants already established in the project area. The species that have been used in sand dune stabilization are shown in Table 2.

Direct broadcast seeding of both woody and grass species has been done. Hand broadcasting and broadcasting from aircraft have been tried. Generally, broadcasting has been less effective than transplanting.

Table 2 : Species Used in Dune Stabilization.

1. Tamarix striota
2. T. pallissi
3. Haloxylon persioum
4. H. aphylla
5. Calligonum polygonoides
6. Sueada rosemariana
7. Atriplex canescens
8. A. halimus
9. Zizyphus spinachristi
10. Acacia farnesiana
11. Prosopis juliflors
12. Populus euphratica
13. Panicum antidotale
14. Pennisetum dichotatum
15. Aristida pinnata
16. Alhagi camelorum
17. Prosopis step aniana
18. Halocnemetum strobilaceum
19. Eucalyptus camaldulensis
20. Sedlitsia spp.
21. Callatropis procesa
22. Imperata cylindrical

Note: Species numbers 1, 2, 3, 13 and 15 are most frequently used.

All areas included in the stabilization projects are placed under protection. No cultivation or livestock grazing is permitted. As a result there has been, in most areas, a recovery of native vegetation in the interspaces between the planted species and in areas that were not treated. This recovery of native plants has been so substantial in the older project areas that management plants that will provide for livestock grazing in the area are now being prepared.

Before transplanting the young plants on the dune field, it is required to fix the sand dune temporarily. For this purpose, two different methods have been used: (1) mechanical method, (2) chemical method.

Mechanical Method

In temporary fixation of sand dune by mechanical method, windbreaks and palisades are constructed to lift the wind off the sand surface. The spacing, geometric design, orientation and height of the windbreaks and palisades vary according to site conditions and severity of wind velocity. Native vegetations such as *Ferula Galvanifera, Aristida Pinnata* and *Imperate Cylinderica* or any other local species in adjacent land to project area which are suitable to reduce sand movement are used to construct windbreaks and palisades. The most important activities of sand dune stabilization in Iran using mechanical method have been done during the period of 1965 to 1980 (Table 3).

As mentioned above, the other procedure for temporary sand dune stabilization is the application of chemical mulch. The application of any of these two methods in any project area depends on the following factors:

a) The severity of sand movement

b) The height of dune
c) The degree of success to be expected from the activity.
d) The main purpose of sand dune stabilization
e) The availability of windbreak material
f) The necessity of sand dune stabilization

Table 3 : Sand Dune Stabilization Activities, (1965-1980)

Activities	Quantity	
Protected area.	2351980	ha
Windbreaks establishment	6745	km
Shrub transplantation	341186	ha
Shrub replants	826465	ea
Bagged plant	17935976	ea
Seed collection	5945517	kg
Broadcast seeding	735413	ha
Nursery area	692	ha
Road construction	600	km

Chemical Method

In this method, chemical mulch is applied for temporary stabilization of sand dune. Petroleum mulch is one of the various heavy products of refined oil, which is produced by the Ministry of Oil of Islamic Republic of Iran.

The chemical mulching project is an independent operation that came into existence in 1968 to satisfy the need to obtain immediate control of dune as a temporary fixation measure creating conditions for the establishment of permanent vegetative cover. This was in the Boinzohra area, approximately 120 km. west of Tehran, where an area of 900 ha. was sprayed and planted, mainly by hand, using a Mercedes Benz tank truck and a piping system with pumps giving a delivery pressure up to 300 P.S.I.

In these early experimental days the quantity of petroleum mulch applied varied. Heavier treatment was given to exposed dunes and slip faces, lighter treatment to hollow and sheltered faces. But a rough average was established at 3.85 tons of peroleum mulch per hectare.

The mulch project has developed from a simple operation when a bituminous mixture was applied from hand sprayers and back packs to a highly improved operation in which giant tanks mounted on sleds are pulled over the sand dune by track laying vehicles. The mulch is sprayed from nozzles mounted on long booms and from "jet" guns, so that a swath about 15-25 m. wide is treated with each pass of the equipment.

This method has some advantages, because it may provide better conditions for establishment of seedlings. Some of these advantages are as follow:

- Stabilization of the whole surface of the sand dune.
- Petroleum mulch cover the sand surface as long as 2-3 years.
- No root exposure in high winds.

This method is widely used in some sand dune fields in Iran, and because of it success some of the Gulf Nations, such as Abu Dhabi have been encouraged to apply this method for stabilization/ afforestation of the dune field area. At present, the Islamic Republic of Iran has a contract with Abu Dhabi for controlling 3,000 ha. of dune field using petroleum mulching method. The project is expected to be completed with satisfactory result next year. The treated areas using this method are shown in Table 4.

Table 4 : Treated Areas Using Petroleum Mulch Method.

Ostan (Province)	Location	Area (ha.)
Khuzistan	Ahwaz	52546
Khorasan	Sarakhs	4871
Hormozgan	Bandar Abbas	3257
Kerman	SirJan	1700
Bushehr	Bushehr	2538
Central province	Boinzahra	1250
Isfahan	Isfahan	186
Bluchistan	Zabol	6549
Abu Dhabi	Abu Dhabi	1160
Total		74057

NEPAL

Implementation of the Plan of Action to Combat Desertification

Introduction

The Kingdom of Nepal, though limited within a land-locked area of 141,059 sq.km. with its hilly part occupying about 77 per cent of the total area, happens to be a unique peace-loving country in the world because it is bestowed with a wide range of climate, rainfall, vegetation, soil, wildlife and, above all, bewitched topography, the highest parts of which constitute the quantitative majority of the loftiest mountain peaks of the world.

Considering the existing total population of about 14.3 million (1980) with an annual growth rate of 2.3 per cent or more, the country is more densely populated than any other country in the ESCAP region. About 90 per cent of the population are subsistence farmers engaged in farming and 40 per cent of the families are below the poverty line. The average national ratio of arable land to man is 1 hectare to 9 persons.

There is not much scope for bringing new lands under cultivation particularly in the hilly region of the country. The overall economic situation is poor as indicated by the low per capita income of $US123 per year. Poor public health, sanitation, transport and communication networks are additional social constraints. However, for the last two decades or so the country has been trying to ameliorate the living standard of the people through various national developmental endeavours and projects with internal resources as well as international, bilateral or multilateral support and assistance.

Now His Majesty's Government (HMG) and the people are gradually becoming appraised of the situation created by the threat and consequences of desertification processes in the country, particularly as a result of increasing pressure of population on land and their uprecedented effort to meet minimum basic needs at an expense of environmental degradation and depletion of life-supporting natural resources. In spite of the pressing demand and urgency to fulfill the present aspirations of the people for a better life system, the Government has taken necessary steps to include in eco-developmental activities some long-term regional and national projects that would go a long way to solving directly or indirectly some of the growing problems of desertification in the near or distant future. For example, there are about 50 completed or on-going developmental projects related one way or another to desertification problems. Mention may be made of Integrated Watershed Management; Torrent Control and Land Use Development; Community Forest Development; Resettlement in Terai; Integrated Mountain Development; Livestock Development; Water and Power Development; Integrated Fishery and Fish Culture Development; National Parks and Wildlife Conservation; Population and Family Planning; Agro-Meteorology Consultancy Service; Small Farmers Development; Sheep, Goat and Wool Development; Appropriate Alternate Source of Energy and several such other national or regional projects, all of which are oriented to support the eco-developmental activities of the nation. Though the number and extent of UN systems, bilaterally and multilaterally assisted multi-developmental projects have been of much significance to the country's socio-economic developmental needs, yet for a Least Developed Country like Nepal, with very limited internal resources and exceptionally low national income, much more foreign support and aid than now provided would be needed not only to widen the scope and pace of development nationally but also to help the Government and people to build up and improve the country's life system on sound environmental lines.

Ecological Setting

The mountain ranges, plains and the river system which divide Nepal into a number of natural regions are ecologically classified into five major zones, enumerated from the north, bordering China, to the south, facing India. Not only do they show visible differences in their topographical, climatical and geomorphological features but also in their watershed, soil fertility, vegetation and human conditions that have to some extent influenced the zonal socio-economic-cum-cultural pattern. The zones along with some of their known characteristics* are presented below.

I. The High Himalays Zone occupies 23 per cent of the total area of the country, located between the forestline, at 4,000 metres to over 8,000 metres above sea level. Watershed condition has generally not been influenced by man's activities; glacial erosion is dominant; climate is tundra to cold steppe; very low rainfall; sparsely populated; meadows on lower slopes have low shrubs; valley slopes are greatly degraded due to overgrazing; environmental disorders due to almost year-round tourism are conspicious in some areas.

II. The Transition Zone extends over about 18 per cent of the hilly country and lies below the above zone, bounded roughly between the elevations, 2,300-3,000 and 4,000 metres, though in some areas its southern margin drops to 1,000 metres. Topographically, the zone has dominant long, steep slopes; valley slopes are usually forested; climate is humid continental suited marginally to agriculture; the valleys are part of important watersheds most of which are still in quite good condition but highly vulnerable to erosion; population density is moderate to low. The zone is usually too high a land for, and climatically unsuited to, human settlement.

III. The Middle Mountain Zone is the largest of the five and the most populous one with almost two-thirds of Nepal's population living in an area of 42,000 sq.km. or 30 per cent of the country. The zone is popularly known as the Midlands or the Middle Hills. There is a wide elevation range from 200 metres at the lowest part of the zone to about 3,000 metres at its highest part. Most of the zone maintains have a temperate monsoon climate with cool, dry winters and wet, warm summers; annual rainfall ranges from 3,500 mm to less than 1,000 mm; only 25 per cent of the original forest cover is now left and much of this is becoming impoverished.

Due to high population pressure the carrying capacity of the present farming system has been exceeded, agricultural yields have declined, pastures are over-grazed and the forests have been recklessly removed. All these constraints are seen to be indicators of desertification in the area which is obviously passing through a difficult period both physically and sociologically.

IV. Siwalik Zone. This zone makes up 13 per cent of the country's hilly land area; the watershed condition is fair but with a high potential rate of natural erosion. Altitude is 600 to 2,000 metres; high population pressure on land in places and mostly forested with very coarse-textured soils.

V. The Terai Zone. This is spread over 16 per cent of the country's land area composing the southern Terai plains of Nepal; erosion by water is not significant although certain small areas in the far eastern Terai and in the braided river flats are prone to wind erosion, particularly in hot, dry season; the zone is 25-30 km. wide with lands with deep water table abutting the Siwalik foothills; the climate is sub-tropical with a wide annual rainfall range varying from 500 mm in the west to 1,500 mm in the east: soil is very fertile particularly in the southern part of the zone; it is the abode of one third of the country's population with a high density of 180 persons per sq.km., the land under cultivation constitutes 66 per cent of the Kingdom's total cultivated land; population per hectare of cultivated land is about 6 persons and land holding is 1.5 ha per family.

Most of the rivers in the Terai give rise to flood problems which often cause immense damage to nearby agricultural lands, villages, roads, bridges and irrigation schemes.

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* Watershed condition is defined here as the present condition relative to the undisturbed condition and therefore does not take geologic erosion into consideration.

About 7 per cent of the entire Terai is occupied by the flood plains of the various rivers. This represents an area of about 1,300 sq.km. which is subject to annual damage.

EVALUATION OF DESERTIFICATION AND IMPROVEMENT OF LAND MANAGEMENT

General Desertification Scene

A two-man fact finding Desertification Mission, sponsored by UNEP, visited Nepal from 8 to 16 May, 1980, with the specific purpose of discussing with HMG the importance of a suitable national plan of action to combat desertification as an integral part of an overall national development plan and to offer suitable assistance from UNEP to the Government for any project proposal related to combating desertification on which the Government may place high priority. The Mission discussed the issue of desertification with the concerned government officials and also with the country representatives of UNDP, World Bank, FAO and other persons from organizations that have been supporting various development projects and schemes, and which are intended also to control desertification in the country. It was observed that out of a total of 201 foreign-aided pre-investment and technical assistance or capital assistance projects in Nepal, about 50 partly or entirely impinged on desertification. As a result of its contacts and observation, the Mission identified three major environmental problems which are now threatening quite a large portion of the country with serious desertification. The problems were reported to have arisen mainly from the following activities of man:

1. Widespread deforestation: it is usually caused by indiscriminate tree-felling to meet the increasing demand for fuel requirement and construction, by forest clearance for lands for agriculture and also by the Government's action to rehabilitate the hill labour migrants in the available forested plains of Terai and other areas where forests were cleared to provide them with farmlands.

2. Lack of effective soil conservation measures on cultivated lands: the short-sighted economic-oriented development activities in an effort to cultivate the rain-fed steeply sloping lands and other erosion-prone areas is an immediate cause of soil erosion. So is action to implement resettlement plans in the 'pristine' areas of the Terai where clearance induces wind and water erosion, and also the irrigation of land without paying due attention to proper drainage and tail-water disposal.

3. Over-grazing in many parts of Nepal including the semi-arid part of the country opening to the Tibetan Plateau: the grazing pattern in the area has changed considerably because of forced grazing over limited pastureland round the year. This has led to over-grazing and consequent desertification of the rangeland in that area. An equally desperate situation is occurring in hill areas due to over-grazing.

In sum, the regions indicating the symptoms of various desertification processes and their effects in Nepal were found in (1) the arid region, of the Trans-Himalayan Range, which was heavily over-grazed; (2) parts of the humid mountains and hilly region where as a result of population pressure on land, accelerated soil erosion and frequent landslides are symptoms of unprecedented degradation of land with a consequent declining trend of productivity and, lastly, (3) the Terai plain, which is exposed to severe floods in each monsoon with increasing trend of bedload deposition in rivers and possibly some wind erosion during dry seasons.

According to the Country Report of Nepal prepared for consideration at the last UN Conference on Desertification, held in 1977, the areas where desertification forces have been found to be very active were in the cold and dry districts of Mustang and Dolpa in the north-central region of the country. Other areas where desertification forces were considered to be active and advancing significantly were located in the Surkhet and Dang valleys in the south-western region, around Okhaldhunga in the Middle Mountains and some in the flood-prone and wind-eroded belt in the Terai plains of Nepal. As a result of a recent countrywide survey as a prerequisite for soil conservation and watershed management programme, altogether 15 different localities in the country, including those mentioned above, were found to be in a severely eroded condition showing signs of advanced desertification.

Land Status

Land use data of the country's total area of 141,059 sq.km. are given as follows: forest 29.1 per cent; land under cultivation, 22.2 per cent under permanent snow, 15 per cent; grass land, 12.6 per cent and others (water, cities, roads, etc.), 21.1 per cent. The cultivated land in Nepal accounts for only 2.3 million ha of which 38 per cent is in the hilly region and 62 per cent in the Terai.

Based on a reconnaissance survey of the condition of watersheds in Nepal, the following five major classes of watershed condition have been identified:

Class 1 – Excellent, Natural or geological erosion active but man is not a threatening agent.

Class 2 – Good. Disturbance due to land-use is minor. Productivity or land is not impaired.

Class 3 – Fair or marginal. Disturbance due to land-use is significant. Productivity is impaired.

Class 4 – Poor. Disturbance by accelerated erosion is serious and causes considerable stream sedimentation and reduced productivity of land.

Class 5 – Very poor. Accelerated erosion is common. Agricultural and forage productivity is absent or greatly reduced. Siltation and extreme run-off conditions have effectively destroyed the natural character of the streams.

13 per cent of the land is in Class 3 or lower which totals 18,200 sq.km. This is a large area to deal with. The condition over most of the country is deteriorating but the rate of deterioration is not known.

There is a remarkable difference in the climatic condition, river system, land-use pattern and soil capabilities between the Terai and the entire Hill region of Nepal. The Terai has frequent flood and siltation hazards. However, soil loss from agricultural land is thought to be relatively low. Population per hectare of cultivated land is much lower than in the Hills. But there has been a continuous migration of hill labourers to the Terai plains, chiefly due to economic reasons. The resettlement of these migrants in the Terai has become a greater environmental problem for the country caused initially by the increasing population trend and followed by a widening gap in the man to cropland ratio in the hills.

The Hill area of Nepal, occupying about 85 per cent of the total area of the country and composing the three ecological zones presents a gloomy picture because about 8.5 million persons out of a total 14.3 million live in the region and cultivated land available to them may be less than 500,000 ha or 9 per cent of the total land under cultivation. The population density per ha of cultivated land is about 14 and the present land holding size is 0.5 ha per family. The population distribution and cereal production are very much imbalanced between the Hills and the Terai, and the Hills are now suffering food deficit. Due to the shortage of good cultivable land, marginal lands including the steep hillsides are being brought under cultivation. The Hill areas of Nepal with least capability of supporting their population have the greatest population pressure on agricultural lands and have little hope for expansion or reclamation.

Forest Status

The forested areas in the various zones have very unequal distribution depending upon the extent of the area deforested. The Terai zone has only 19 per cent forest due to heavy deforestation; the Middle Hills has 28 per cent of forests, much of which is now restricted to steep slopes and the temple surroundings; the Transition Zone maintains forests over 48 per cent of the area, and in the Siwalik zone the forested area occupies 66 per cent of the total area. The forest in the whole country now occupies about 29.1 per cent of the total land area. As an example of deforestation, it was recorded that out of the total of 638,300 acres of forest land in 1928, only 205,000 acres are now left in the eastern Terai and it is forecasted that if the forests continue to decline at the present rate, all accessible forest lands in the hills are likely to disappear within 15 years and those in the Terai within 25 years.

Decline of the entire forest in the country from 6.4 million ha to 4.8 million ha from 1964 to 1974, and to 4 million ha at present, indicates that the forests in Nepal are really in a critical state, and this is particularly true in the Terai and Midland zones where due to the combined pressures of shifting cultivation and demand for fuel and fodder by an increasing population, forests are receeding fast and the barren deforested lands are subsequently exposed to severe degradation through accelerated soil erosion. The deforested and over-grazed areas in the country present a gloomy picture leading to desertification and to growing human distress.

Watershed Status

The overall condition of the watersheds is considered to be deteriorating at an unknown rate. Reckless deforestation, uncontrolled grazing, use of unsuitable lands for agriculture and construction, and abnormal soil erosion were considered to be the direct indicators of the declining state of watersheds. It is an unhappy sign that 13 per cent of the country has unsatisfactory watershed conditions. However, it would be possible to improve the watershed condition in most areas of the country by improved land-use practices such as grazing control coupled with pasture improvement, effective forest management, etc. But it is important to note that the much of the sediment load coming from the Hills to the Terai is derived not from erosion for which man is responsible but from natural or geologic erosion. This is almost impossible to control. It, therefore, means that whilst the flooding and bedload problem of the Terai rivers could be reduced by soil conservation activities in the Hills, flooding and sedimentation will always occur. The physical condition of the agricultural lands of Nepal and particularly of the country's hilly regions is surprisingly good and terracing is a traditional but highly evolved indigenous art in the hills and there is visible evidence that erosion is rare on most terraced cultivated lands. Moreover, most landscapes in Nepal have a high inherent recuperative capacity due to deep soils and a favourable climate. All such land conditions and behaviour are favourable to effective rehabilitation of abused lands with consideration for periodic rest and protection from use.

Agricultural Status

The traditional system of agriculture is the main, if not the only, occupation and primary source of income for over 90 per cent of the people or Nepal, most of whom are subsistence farmers. Nearly 80 per cent of the total exports of the country are dependant upon agricultural production. Generally, Terai agriculture is much better off than that of the Hill areas in terms of food production, and there is a food deficit in the Hills whereas the Terai is a food surplus region. Statistical data for 1980 show that out of the total average production of 37.41 million tons of cereal grains, the contribution of Hill production was about 13.69 million tons and the rest, 23.72 million tons, was produced from the Terai. The agricultural production pattern in Nepal is, however, very much conditioned by geographical and climatic factors. Due to much higher population pressure on cultivated land in the Hills than in the Terai, the cultivated land in the Hills per head is 0.12 ha whereas in the Terai it stands at 0.23 ha per head. Also, the size of the farm holding per farm household between the two regions differs greatly; in the Hills the average figure was estimated at less than 0.5 ha and in the Terai 1.5 ha.

Hill Migration Situation

The ecological imbalance, created by the voluntary migration of a sufficiently large number of landless hill labour to the Terai plains, essentially in quest of food and employment, has been interfering with the development activities in the Terai and at the same time disturbing the hill economy. The migration has so much accelerated in recent years that it has been a matter of great concern to planners and policy makers to systematize encroachment and forced settlements and also to draw up new settlement programmes in the Terai. This is an additional burden on developmental projects.

Social factors in out-migration from the Hills are partly responsible but economic ones are predominant due to sharp disparities of income, productivity, job opportunities and economic status between the two regions. Hill migration to the Terai is likely to be speeded up in future if the population goes on increasing at the present rate in the country and particularly in the Hills where arable lands are limited. The impact of in-migration in the Terai could well be further encroachment on forests and progressive degradation of forest areas. Such a process of deforestation by human forces may in the long run threaten both the old and the new human settlements with desertification if suitable action to check and minimize migration and to provide the peoples' basic needs is delayed inordinately.

Soil Situation

According to the recent survey by the Department of Soil Conservation and Watershed Management, widespread degradation of soil resources is considered to be a serious national problem cutting across almost all spheres of the society in Nepal. As the better quality of soil has developed under the protection of vegetation in the Hills and the Terai, the continued reckless removal of vegetation by man and livestock has accelerated soil degradation. This affects the environment in several ways; loss of soil fertility, siltation of downstream rivers and blocking of stream channels together with landslides and phenomenal soil erosion in the country. If the present trend is allowed to continue the day is not far off when the forces of desertification will create a situation that will not only be difficult but also very expensive to control.

Erosion Situation

Geology, topography and climate are the three major ecological factors which contribute most to natural erosion which includes landslides in the country. Younger mountain ranges like the Himalayas have a greater natural erosion potential, particularly if the range is high. The main reasons for accelerated erosion are due to man's activities; overpopulation and improper land-use practices. Due to over-grazing and deforestation in the hill region, the vegetation-free land is subjected to splash erosion, followed by development of rills and eventually gullies and landslides. The sloping and unterraced fields are most vulnerable to rill and gully erosion. Torrents and sheet erosion are common in deforested uplands. Sometimes excess irrigation water causes formation of gullies on slopes. The integrated soil conservation measures, which are now being initiated, are meant to combat accelerated erosion before a greater havoc through desertification processes occurs.

There are, however, some encouraging facts about the state and distribution of soil erosion and the climatic condition in Nepal which are helpful to soil conservation measures. Though soil erosion is widespread it is still relatively minor or insignificant in many parts of Nepal, where the climate is also conducive to good plant growth and the sub-tropical soils are usually deep and fine-textured and so are not severely eroded.

As Nepal falls very much outside the well-known arid zone of ESCAP region, recommendation 4 of the Plan of Action to combat desertification is not applicable to this country.

Public Participation in Preventing and Combating Desertification

Desertification is as such a result of over use or misuse of natural resources. Over use as a result of population growth and misuse because of ignorance still continue. Villagers lack the realization that they take more from nature than they give. If this trend continues in the years to come there will be hardly anything left for the use of future generations. Therefore, a balance in the ecosystem can only be made if the people understand and undertake optimum use and better management of the natural resources.

In order to get this, villagers are being given education on soil and water conservation at its related fields through the conservation education extension programme of the Department of Soil Conservation and Watershed Management. They have been encouraged to grow more trees by supplying them with fruit plants and forest seedlings. Terrace improvement programmes where HMG pays

70 per cent of the total improvement cost has played a significant role in places in getting people to appreciate the causes and effects of and remedies for desertification.

This aspect will be an integral part of the four-year HMG/UNDP/FAO project Nep/80/029 "Watershed Management and Conservation Education", HMG/USAID Resource Conservation and Utilization Project and HMG/Swiss/German Tinau Watershed Project.*

DESERTIFICATION CORRECTION MEASURES

Water Resources Planning Development and Management

Recently the Government has set up a Secretariat of the Water and Energy Commission, which is to be the national co-ordinating body with comprehensive responsibility for collecting water resources data and establishing a water resources data bank.

The Department of Irrigation, Hydrology and Meteorology has networks of meteorological, hydro-geological and hydrological stations located in different parts of the country. Every year new stations are added to the network. Their responsibility is to collect, process and publish hydrological (surface and ground water) and meteorological data every year. So far no action has been taken to assess the surface and ground water resources in terms of water balance in any part of the country. The Water and Energy Commission was formed and is authorized to co-ordinate the activities of all organizations responsible for the investigation, development, and management of water resources through proper institutional arrangement.

For effective use of water for irrigation and supply to industries, measures are on the way to distribute water to the consumers on a volumetric basis by the concerned line departments and corporations. Line departments such as the Department of irrigation, Hydrology and Meteorology and the Department of Mines and Geology have capabilities necessary for geohydrological and geophysical surveys for detecting and assessing ground water. Remote sensing techniques are used by the Department of Soil Conservation and Watershed Management to assess the locations of landslides and areas affected by floods. Analog and mathematical models are now being used for data processing of water resources in some areas, for the design of irrigation channels and river behaviour from the viewpoint of flood control and reservoir operation.

Though community water supplies are now available to many remote rural areas, most of the areas showing signs of desertification have not been provided with this facility so far.

Ground water in the Kathmandu valley was found to contain gas and traces of iron and sulphur. The Government is thinking of harnessing this gas for cooking purposes and the water for drinking and industrial purpose after further treatment. Since the Terai area has a large storage of ground water, which is usually fit for drinking, irrigation and industrial purposes, plans are under way to harness it also.

Range Land and Livestock Development

The total livestock population in Nepal is 21.39 million, including poultry, cattle, goat, buffalo, sheep and pigs. Ruminant livestock is concentrated in the hills. During the last decade cattle, sheep and goat populations have been increasing whilst the buffalo population is decreasing. Since the indigenous ruminant livestock is low in productivity, an upgrading programme has been started in most of the districts of Nepal. Various integrated rural development projects are providing the basic inputs and technical services to livestock raisers.

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* Plantation as well as the protection of existing forest with the people's participation is being done with help from HMG/World Bank/FAO Community Forestry Project.

Range land has an area of 1.78 million ha or 12.7 per cent of the total land was of Nepal. It has been ecologically classified as alpine meadows in the High Himalayan ranges above the tree line, steppic grazing land scattered over a large area from sub-tropical to cool temperate zone.

Increases in population and free range grazing have exploited the natural vegetation. For the development of livestock or population, productivity has to be increased in the mid-hills. At present in the mid-hills and mountains, the total feed available for ruminant livestock as a percentage of requirement is about 54 per cent and unfortunately has a negative trend.

The present level of range land productivity could efficiently maintain only 47 per cent of the cattle and 50 per cent of the buffalo population in the hills and mountains.

Various watershed management projects have also taken up range land improvement programmes. Grass land improvement could be based upon silivipasture system in the mid-hills integrating forest plantation and herbage production. Partial re-seeding at lower elevations and grazing management would greatly increase the carrying capacity of alpine meadows and range management in steppic grazing land would aim to increase the ground coverage.

Barren or open grazing land and some parts of wasteland could be gradually converted into productive grass land.

A range land improvement programme is a multi-disciplinary action and is much affected by the land-use system. Appropriate technology development and peoples' participation would be the prerequisites for such work and action has been initiated along these lines.

Soil and Water Conservation Measures on Rain-Fed Agricultural Lands.

In order to ensure a positive response to development of the rain-fed agricultural land, such areas will be accorded simultaneous inputs. Integration of various activities in different fields such as agronomy, horticulture and livestock development is the approach taken to increase the agricultural production in rain-fed conditions. Such activities include terrace improvement, irrigation supply, distribution of improved varieties and introduction of better practices. Pasture development range management and silvipasture will have a positive impact in gaining increased soil fertility, protecting watersheds and conserving soil and water. Animal husbandry improvement by the introduction of improved stock and cross breeding will also be done.

Horticulture, though it occupies a small portion of agricultural income, if developed substantially can aid in augmenting of agriculture production. Therefore attempts will be made to accomplish this by the distribution of saplings, minikits and development of kitchen gardens. Farmers will be provided with credits and subsidised inputs.

Development and Management of Irrigated Lands

The target of the fifth Five-Year Plan was to irrigate 146,000 ha, but only 95,000 ha of cultivated land has been irrigated. In the forthcoming sixth Five-Year Plan the target is to irrigate 245,316 ha of cultivated land and the budget allocated for this is Rs. 864 million ($US72.6 million). Seeing the problem of migration from hills to Terai, more emphasis is being given to upland irrigation in the hills.

The Hydrology Section of the Department of Irrigation Hydrology and Meteorology is responsible for collecting water resources data. There is a plan to establish a water resources bank in the near future.

Networks of meteorological and hydrological stations are being extended across the country as a whole, but specific requirements, availability of manpower and equipment and operational hardships constrain the implementation.

Action to assess surface and ground water resources in terms of water balance has not yet been taken.

Flood control works are also handled by the Irrigation Hydrology and Meteorology Department and these activities have been concentrated mainly in the Terai area to protect the villages and high investment infrastructure.

Protection of Vulnerable Lands

The strategies used in protecting vulnerable land including land prone to mass movements will be based on structural and biological techniques. The technique selected or combination thereof will be based upon the specific site requirements.

Conservation of Flora and Fauna

The main problem of wildlife conservation in Nepal has been to check and control the activities of the growing population in forests and rangelands, which are being mercilessly cleared endangering the survival of much wildlife in their natural habitats. This has been more conspicious in the Terai region where excellent wildlife habitats were wantonly destroyed by the hill migrants for use as agricultural land and settlement. However, considerable success has been achieved in conserving the habitats of endangered species at the Royal Chitwan National Park and other reserves.

Almost similar is the situation in the Trans-Himalayan areas, where immense damage has been caused to the rangeland by over-grazing. To protect the very fragile eco-systems in the Trans-Himalayan region, a national park is proposed to be established in the Shey-Phuksondo area. Three national parks have already been established in other high Himalayan areas. Strong measures are being taken to protect the national parks particularly, in the areas vulnerable to desertification.

Action which has been proposed to be taken to implement better wildlife management in the country includes, among others, preparation of management plans for Royal Chitwan National Park, Karnali-Bardia Wildlife Reserve and two other national parks, survey and field investigation of five hunting reserves and research on tiger ecology. Attention has also been given to monitor conditions in some of the wildlife habitats vulnerable to desertification.

Environmental Monitoring

It is necessary to conduct inventories and build up an on-going mechanism that evaluates techniques now applied, in order to plan for the future. Monitoring will include information on hydrology, geology, soils, land capability and erosion. Detailed surveys will be conducted for all these disciplines. Data collection will be from satellite imagery, aerial photographs, climatological stations and other sources. The actual conservation techniques will be measured against erosion reduction, water quality changes, sedimentation reduction in streams, land-use changes and other changes in the environment.

During the sixth Five-Year Plan, a division of the Department of Soil Conservation and Watershed Management, the Environmental Management Division, is to be set up for the above task. Assistance will be received from UNEP for this purpose.

SOCIO-ECONOMIC ASPECTS

Analysis of Man-Made Factors in Desertification

Despite continued effort by the Government and the people for the last two decades or so, the socio-economic condition in the country has not improved significantly for various economic, physical, territorial and social reasons. The continued increasing population growth rate from 8.3 million in 1950 to about 14.3 million in 1980, over which there has been no control so far, has been reducing development programmes at a faster rate than the benefits of development could be felt with the result that overall economic improvement is not attained. The poor economic situation is partly linked with inadequate transport and communication networks. The economic situation in the Hill region with a greater population density of 14-15 capita per ha of cultivated land, is in a more critical state than the Terai region because of deficit in food-grain production (50 kg per person per year), stagnant crop yield under traditional cultivation methods, insignificant provision for irrigational facilities, failure to provide high-yield varieties of crops for the specific needs of rain-fed agriculture and the like.

Since farming in Nepal is the main occupation of 90 per cent of the population and the cultivated land in the country is limited to about 2.3 million ha (hill region 38 per cent, Terai 62 per cent) with little scope for expansion, particularly in the hill region, the model of hill farming system, which is a self-contained one, is now breaking down, chiefly as a result of excessive population pressure on the land resource. Another serious problem emerging which is related directly to socio-economic situation in the country is the continuous migration of hill labour to the Terai for permanent or temporary settlement. The socio-economic as well as environmental imbalance created by this process is more conspicious in the Terai area than in the Hills. The sooner the capabilities of the Hills are increased and developed in the right direction to absorb the growing population the better since the chances of adversely upsetting the socio-economic balances both between the two regions and also within them will be lessened.

Of the major ecological zones in the country, it is now evident that the socio-economic system of the Middle Mountain Zone with its increasing population constrained by the declining economic situation is on the verge of collapse.

Health Care Services and Family Planning

There is a separate Ministry and Department to provide health services to the Nepalese people. There are hospitals and health service centres in almost every district of the country. Various projects like Malaria Eradication, Tuberculosis Control, Smallpox Control etc are also functioning in the country.

The Family Planning Association of Nepal is trying its best to check the population growth in Nepal. It provides services like sterilization and contraceptives to the people of the hilly region which is vulnerable to desertification. Now the Family Planning Association is trying to adapt an integrated family planning approach. The Family Planning Association of Nepal has been generating family planning awareness among the general public through various audio-visual means of communication like radio, posters, pamphlets, booklets, film shows and interpersonal communication etc. Since the trend of population growth is higher in the middle hills and migration is concentrating people in the Terai region vigorous family planning activities are concentrating on these places.

The United Nation's Fund for Population Activities has agreed to support a comprehensive population family planning and maternal and child health programme to the amount of $US26.5 million over five years to assist the Government of Nepal.

The concept of this programme is to strengthen Nepal's capabilities in all aspects of population activities including demographic data collection and analysis, migration and knowledge of population activities at all levels.

Avoidance of Constructing Permanent Buildings in Affected Areas

Policy and legislation to avoid the construction of permanent structures in affected areas is being prepared. Some studies of landslide prone areas and their recognition have been undertaken which have adopted the hazard mapping approach.

Monitoring of Human Conditions

Monitoring of human conditions has been done only during baseline surveys of particular project areas.

EFFECTS OF DROUGHT

The effects of seasonal drought are becoming more severe every year, particularly in the western hills of Nepal. There is a link with deforestation here, since in several cases reforestation has led to perennial water flow in small springs which had ceased to flow all the year round.

Food assistance is provided for the people during scarcity periods. Irrigation facilities are being provided where possible. Integrated rural development projects which have been introduced have the main task of building up the economy of the rural people.

STRENGTHENING SCIENCE & TECHNOLOGY AT THE NATIONAL LEVEL

Application of Science and Technology for National Utilization of Resources

For sometime the country has been facing quite difficult problems of economic growth and equity in distribution of its benefits among the common people of the country. Sacrifice of the equity aspect in the course of achieving more efficiency in allocation of the country's limited natural resources has created a greater problem. To tackle this problem the application and strengthening of appropriate science and technology is now gradually being felt and introduced but slowly because of the poor economic situation coupled with inadequate trained manpower in the country. It is gratifying to note that the rural people, though suffering from economic, educational and social backwardness are not at all averse to the introduction of appropriate scientific and technological know-how, if the benefit of ameliorating their life system is ensured.

The country has been investing considerable resources in science and technology as well as in research and documentation for national development in the past few years. (During the last Five-Year Plan, the aggregated expenditure on research and documentation varied between 1 to 3 per cent of the total annual budget.) A National Council for Science and Technology was constituted in 1976 for formulating and implementing a national science policy and also to promote research and documentation activities in science and technology. Another iimportant sphere of the Council's activity is to disseminate and popularize scientific knowledge among the common people.

With the expension of intensive rural development in the country, the necessity of application of science and technology is being felt more than before. The country has only a few institutions that are fairly well-equipped and engaged in research for their own institutional interest and often of marginal relevance to the broader needs of the country. But some future or on-going international, bilateral or multilateral developmental projects are expected to introduce new science and technology in the larger interest of the country. To quota a few of them, mention may be made of Agriculture Project Services (UK), Assistance to Hill Development (UNDP), Resource Conservation and Utilization (USAID), Tinau Watershed (FRG), Land Resources Assessment (CIDA), a proposal for establishment of Regional Centre for Integrated Mountain Development in the Southern Asian Mountain Systems in Nepal (UNESCO/MAB), Resettlement in Terai (WFP), etc.

Control of the Use of Vegetation as an Energy Source and Research into Unconventional Energy Sources

Demand for firewood as a source of energy will increase at about the same rate as population growth. The exploitation of forests for fuel has for social reasons, become uncontrolled. HMG is aware of this and is actively promoting community forestry whereby the local communities have rights to their own forests and fuelwood plantations.

Efficient use of firewood and wood products by improved stoves and alternate sources of energy such as bio-gas plants and solar heaters are being introduced. Mini-hydro power plants are also being tried at suitable localities. The Tribhuvan University is carrying out research into these aspects.

Prioritisation of Training Education and Information Related to Desertification

A certificate level training education in Forestry Development and Management and Soil and Water Conservation is given to student technicians, and an Institute of Renewable Natural Resources is going to be set up in the country this year to provide diploma level training to the professional level staff.

International, regional and national seminars, and workshops are to be organized on an increasing scale to help the technicians of all levels obtain information related to desertification. In service training is becoming available to technicians within the country and short courses outside are provided from time to time.

Apart from all these, short-term basic courses will also be given to villagers as a part of conservation extension programme.

Establishment of Co-ordinated National Machinery

Recently His Majesty's Government has set up a National Council for the Conservation of Natural Resources, under the Chairmanship of the Minister of Forests. It will advise the Government on national strategy, policy and actions before they are promulgated and help to co-ordinate integrated resource conservation and utilization projects and to promote measures to minimize environmental impacts of new dams, reservoirs, irrigation, roads and agriculture development programmes.

NATURAL RESOURCE CONSERVATION POLICY

In the coming sixth Five-Year Plan, the following policies will be adopted to bring land-use into balance with the environment through the whole country:

1. Considering the problems of environment and land-use, firstly the growth rate of population has to be controlled. Hence multi-faceted population activities will be given priority.

2. To bring the environment of the country into balance and to control soil erosion; afforestation, river control and other such programmes will be launched in the important watersheds of the country.

3. Natural disasters like floods, landslides and soil erosion are increasing due to the expanding population and declining forest resources. To control the environmental situation and maintain fertility of soil, environmental aspects will also be taken into consideration in the organization of soil and water conservation programmes.

4. Studies and surveys will be carried out to conserve endangered wildlife; national wildlife conservation centres and national parks will be established in various parts of the country to create suitable habitats for wildlife.

5. Natural disasters like soil erosion, floods and landslides are increasing day by day due to the encroachment on forest land for cultivation. So the tendency for unsuitable land to be used for cultivation has to be discouraged. To diminish peoples' dependence on agriculture, cottage and other small-scale industries based on forest and agricultural products will be developed.

6. Land lying within the command areas of irrigation projects will be used for agriculture only.

7. Rules and regulations to control the environment of urban areas will be reviewed.

8. Agriculture, transport, irrigation, forestry, industry, and tourism affects land-use and environment. Hence to look after the environment and to conserve natural resources a

National Council for the Conservation of Renewable Natural Resources will be established to co-ordinate different disciplines and to conserve natural resources.

9. Industrialization, urbanization and other development programmes pollute both air and water as well as damaging the environment in other ways. So strict rules and regulations will be made to control the pollution of air and water.

10. Environmental education programmes will be launched to teach the people how to conserve and protect natural resources and how to balance land-use with the environment.

11. Policy will be adopted so that large-scale civil engineering works do not affect the environment. Studies of the impact of big structures on the environment will be carried out and the necessary training in environmental conservation will be conducted.

INTEGRATION/REGIONAL/BILATERAL/MULTILATERAL ASSISTANCE AND CO-OPERATION TO COMBAT DESERTIFICATION

Various agencies are involved in projects directly concerned with watershed management and therefore with desertification etc. These include United Nation's Environmental Programme, Food and Agriculture Organization, United Nation's Development Programme, Man and Biosphere, United Nation's Education Scientific and Cultural Organization, United States Agency for International Development, Swiss Association for Technical Assistance, Federal Republic of Germany and Economic and Social Commission for the Asia and the Pacific.

Other projects that often have a soil and water conservation component including desertification are Asian Development Bank, International Bank for Reconstruction and Development, Overseas Development Ministry (United Kingdom) and the Government of Canada.

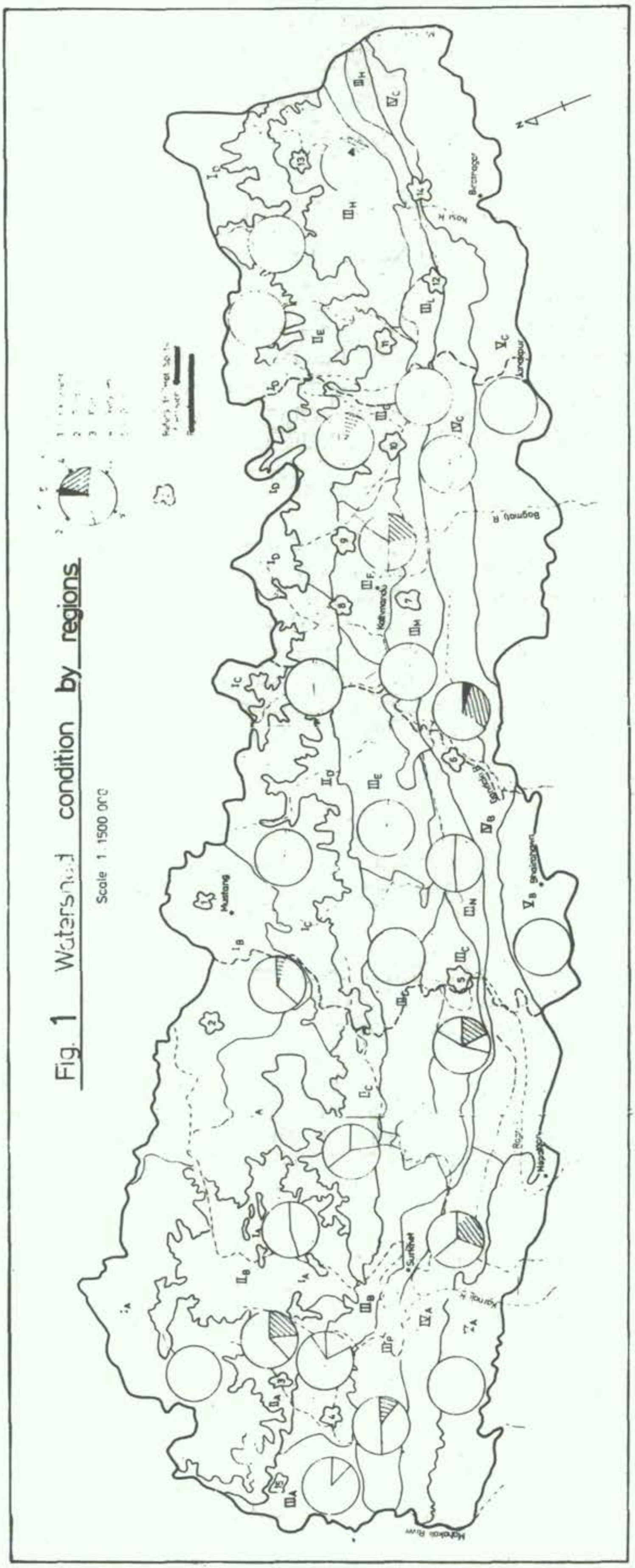

Fig. 1 Watershed condition by regions
Scale 1:1500 000

PAKISTAN

Country Report

GENERAL FEATURES

Location

Pakistan comprising the provinces of the Punjab, Sind, North Western Frontier Province (NWFP) and Baluchistan covers an area of about 80 million ha. It lies between longitudes 61° and 76° E and latitude 24° and 37° N and is bordered on the north by China, on the north-west by Afghanistan, on the west by Iran, on the south-east by India and on the south-west by the Arabian Sea.

Physiography and Hydrology

Physiographically, the country comprises five major physical regions, viz the Northern Mountains, the Western Bordering Mountains, the Salt Range and Potwar Plateau, the Indus Plains and the Baluchistan Plateau. Hydrologically, the country is divided into three distinct hydrological units, viz the Indus River Basin, the Closed Basin of Kharan Desert and the Makran Coastal Basin. The Indus Plain formed almost entirely by the deposition of alluvium is the most important physiographic unit as it contains the main irrigated areas of the country (see Fig. I). It is divided into two parts: (1) the Northern Zone comprising the Upper Indus Plains covering an area of about 14 million ha and (2) the Southern Zone comprising the Lower Indus Plain covering an area of about 6 million ha.

Climate

The climate of Pakistan is characterised by large seasonal and diurnal fluctuations in temperature and rainfall. Temperature extremes generally range from sub-zero to as much as 46° C and the mean annual precipitation ranges from less than 100 mm in the southern parts to more than 1,000 mm in the northern areas, making the region a land of great climatic contrast.

In the greater part of the Indus Plains the climate is arid to semi-arid. The summers are very hot with average maximum temperature of 38° C to 40° C. The annual rainfall varies from about 100 mm in the south to about 750 mm in the north with an average of less than 250 mm. Most of the precipitation occurs in the monsoon period (July to September) when torrential rains sometimes produce one-third of the year's rainfall in a single day. The evaporation rates are very high. The theoretical annual evaporation in the Northern Plains is about 1,500 mm and in the Southern Plains about 1,900 mm. The humidity generally increases after the relatively dry winter months, though springs to high values during the monsoon period and then drops in the late September or early October.

Population

The recorded population of the area falling within the territory of Pakistan was about 16 million in 1901 rising to about 34 million in 1951 and 65 million in 1972. The present estimated population is about 72 million with an average growth rate of 3 per cent.

According to the 1972 Census about 71 per cent of the people live in the rural areas and the remaining live in the urban areas. The average density of population in the country is 81 per cent per sq.km. ranging from about 7 persons per sq.km. in Baluchistan to 205 in the Punjab. Literacy is around 20 per cent and fewer than 50 per cent of the children are in primary schools.

Karachi is the most populous city with a population of 3.58 million followed by Lahore with 2.16 million. There are 19 cities with a population of over 100,000 persons in the country. The distribution of urban and rural population is given in Table 1.

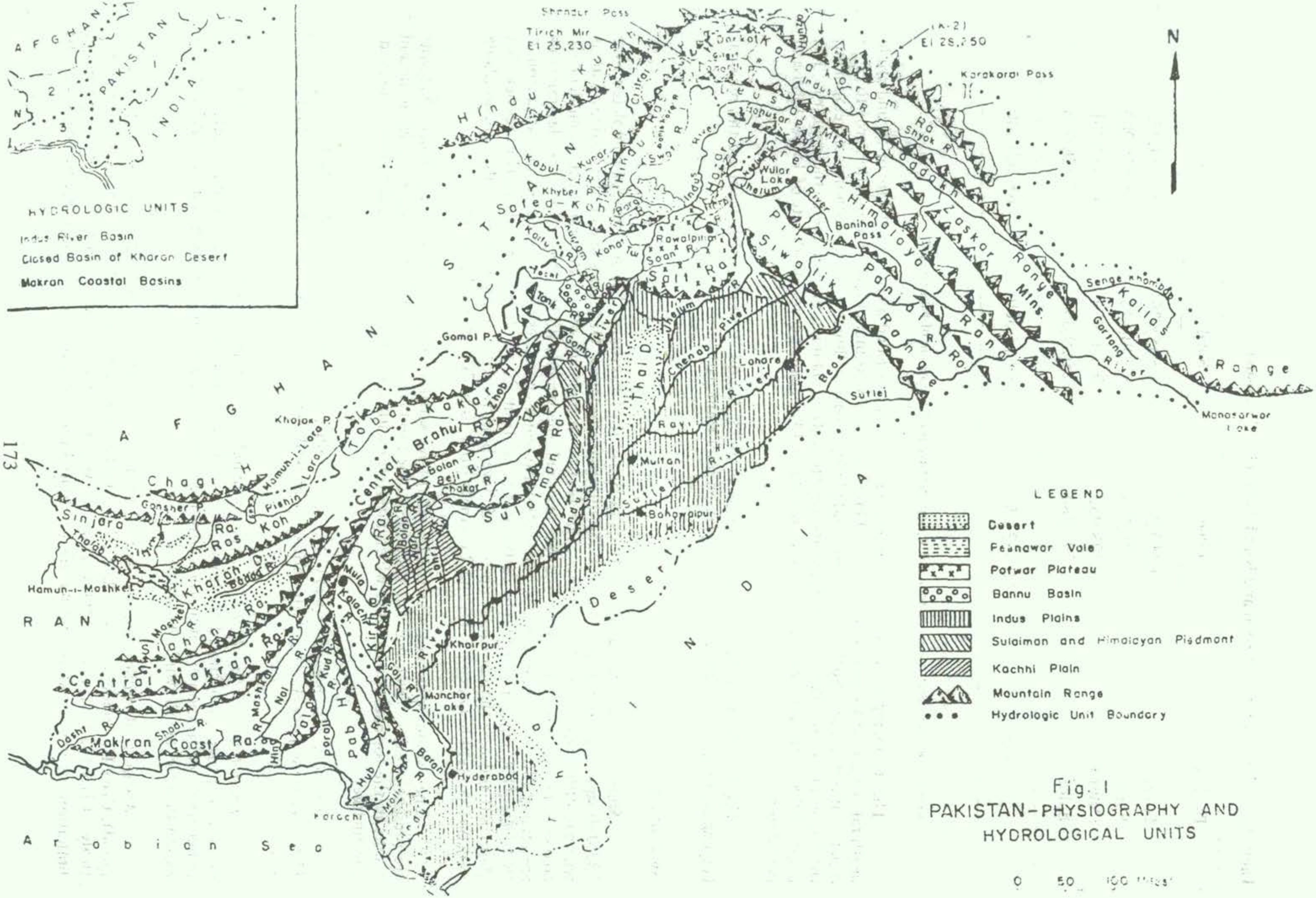

Fig. I
PAKISTAN-PHYSIOGRAPHY AND HYDROLOGICAL UNITS

Table 1. Population of Urban and Rural Areas (1972 Census)

Province	Urban	Rural	Total
Punjab	9,259,336	28,585,636	37,844,972
Sind	5,725,776	8,430,133	14,155,909
(NWFP)	1,208,955	9,670,826	10,879,781
Baluchistan	399,584	2,029,094	2,428,678
Total	16,593,651	48,715,689	65,309,340

Source : Pakistan Statistical Yearbook, 1978, Statistic Division, Government of Pakistan, p. 6.

The demographic analysis carried out in 1965 had revealed a crude birth rate of 50 and crude death rate of 20 per thousand per annum. This indicated an estimated rate of population growth of 3 per cent per annum. Such a high growth rate being a serious threat to socio-economic development, the Government of Pakistan embarked upon a population planning programme in the country. The latest (1975) estimates showed a crude birth rate of 44 as against crude death rate of 15 per thousand per annum.

Urdu is the national language whereas Punjabi, Sindhi, Pushto and Baluchi are the regional languages. English language continues to play an important part.

Agriculture

Soils : There are great variations in the soils of Pakistan. The soil surveys completed over 233,000 sq.km. have established about 250 different soil series. Of these some occupy extensive areas whereas others are of limited extent. The texture of majority of the soils ranges from moderately coarse to moderately fine. Coarse and fine textured soils occur with less frequency. The clay minerals are mainly illite and chlorite types. The cation exchange capacities of the soils generally range from 8 to 16 meq/100 gm. In most soils, carbonates range from 20 to 50 per cent. The pH varies between about 8.0 and 8.5, though values up to 10.5 have been recorded in highly sodic soils. The available moisture content between pF 4.2 and 2.0 ranges from 20 to 30 per cent by volume.

The normal soils (not affected by salts) have satisfactory permeability rate. Where fine salts are present, weakly developed soil structure in the top layer due to lack of organic material in the soil results in the formation of a crust which interferes with water infiltration, and, therefore, with seedling emergence.

The soils are characteristically deficient in nitrogen, organic matter and available phosphorus. There are some pockets of potash deficiency as well, especially in the rice tract and the submontane areas.

Land Use and Capability : Approximately half of the country consists of mountains and deserts; a quarter is occupied by towns, rivers, canals, roads,, etc. Hence less than a quarter remains either under cultivation or within the cultivable command ares of the irrigation system. The land utilization statistics are shown in Appendix I.

About 14.4 million ha. are under irrigated agriculture of which Class I (very good), Class II (good), Class III (moderate) and Class IV (poor) lands occupy 33, 44, 17 and 4 per cent area respectively. Class I land has no limitations and has very high potential while Class II land has only minor limitations of various kinds and has high potential for crop production. The other two classes i.e. III and IV have increasingly severe limitations for agriculture use. The land capability classes are shown in Table 2.

Table 2. Extent of Different Land Capability Classes in Irrigated Areas

(million hectares)

	Punjab	Sind	NWFP	Total
Geographic area	20.66	14.51	10.18	43.35
Total area surveyed	17.50	9.05	3.45	30.00
	Punjab	**Sind**	**NWFP**	**Total**
Land capability of irrigated area				
Class I	3.62	1.04	0.16	4.82
Class II	3.56	2.51	0.37	6.44
Class III*	1.22	1.29	0.04	2.55
Class IV	0.51	0.11	0.004	0.62
Total	8.91	4.95	0.57	14.43

* Approximately 30 per cent of this land is at present under irrigation, the rest is uncultivated.

Crops : There are two main cropping seasons; Kharif – the summer season from April to October, and Rabi – the winter season from October to April. Important crops sown in summer are cotton, rice, maize, and sugarcane. Winter crops are wheat, gram, barley, tobacco and oilseeds. Agricultural production is largely subsistance oriented, with foodgrains occupying major part of the crop acreage.

The crop yields in Pakistan are among the lowest in the world. Shortage of irrigation water in general, and at the critical time of crop growth, in particular; lack of drainage; saline and saline-sodic soils; impure seeds; low levels of fertilizer input; antiquated farm implements; extremely inadequate plant protection measures; unsatisfactory agricultural and irrigation practices and imbalances in inputs are the main factors responsible for the low yields.

Livestock : The size of the existing livestock held in Pakistan is uncertain. Despite the great importance of livestock in total agricultural production, the keeping of animals in haphazard: livestock plays a subsidiary role in the mixed farming system of the country. The livestock population consists mostly of scrub animals with poor genetic qualities. Many of the animals are underfed. Indiscriminate breeding is widely practised. The rural population appears to be fairly well supplied with milk and milk products, but effective distribution system for making milk and milk products widely available in the towns are almost non-existent.

Water Resources

The water resources of Pakistan include surface water of the Indus River and its tributaries, local rainfall and usable ground water from the aquifers underlying the Indus Plains.

Surface Water : The rivers serving the Indus Plains are the Indus and its major tributaries – the Kabul on the right bank, and the Jhelum, Chenab, Ravi, Beas and Sutlej on the left bank. With the implementation of the Indus Water Treaty (1960) between Pakistan and India effective April 1970, only rivers Indus, Jhelum and Chenab have fallen to the share of Pakistan. These rivers flow in shallow meandering channels across the vast alluvial plains which gently slope towards south to south-west along the rivers with extremely flat gradients from about 0.02 per cent in the Punjab to as low as 0.01 per cent in Sind. The rivers have individual flow characteristics but they all rise in the spring and early summer with the snowmelt and monsoon rainfall and have a combined peak discharge in July or August. In winter, during the period November to February, flows are much lower being only about less than one-tenth of those in the summer monsoon. The winter flows consist almost entirely of regeneration or bank storage returning to the river after the summer has ended with the fall in the river stages. The annual average flow in the rivers Indus, Jhelum and Chenab and the river Kabul is about $1.72 \times 10^{11} m^3$. The mineral content (total dissolved solids) of the river waters ranges between 100 to 350 ppm from north towards south. The present contribution of the river waters towards agriculture is of the order of $1.23 \times 10^{11} m^3$.

Rainfall : The present contribution of rain to crops in the irrigated areas is estimated at about $7.40 \times 10^9 m^3$ which is anticipated to rise to about $1.23 \times 10^{10} m^3$ as the cropped areas increase in the course of development.

Ground water : The deep alluvia deposits of the Indus Plains from an extensive ground water aquifer. The physical characteristics of the alluvium are generally favourable to ground water development. Keeping in view the irrigation water quality constraints and gradual deterioration of ground water, it has been estimated that about $5 \times 10^{10} m^3$ of ground water can be developed annually most of which would have to be mixed with canal water before use. However, presently about $2.47 \times 10^{10} m^3$ of ground water is available for agricultural use.

Irrigation and Drainage.

Irrigation : Irrigation has been practised in the country from earliest times. In recorded history, the river flow irrigation as an established practice can be traced as far back as the 8th century A.D. when the Arab conquerors differentiated between the irrigated and non-irrigated lands for the purpose of levying land taxes. The oldest form of river flow irrigation is the 'sailaba' or 'overflow' which is still practised on a substantial scale within the active flood plains along the rivers. This form of irrigation, though most primitive, has quite an important contribution to the agricultural economy, as it has inherent advantages; the soils are maintained relatively salt-free and high in fertility because of the periodic flooding of the riverine areas.

The next stage in the development of irrigation was the inundation canal, which drew water during the summer, when the rivers rose above the levels of their inlets and irrigated lands which otherwise would not have received water by natural flooding. The inundation canals are uncontrolled and cannot exploit low river flows. The irrigation activity was limited to relatively narrow strips of land along the rivers. The supply channels depended on uncertain river flows and were inefficient and also rapidly silted up. They were also dangerous because of the disastrous breaches in the flood season. Inspite of these shortfalls the inundation canals did provide limited source of irrigation. The system was improved during the Mughal period though semi-controlled structures to extend the period during which water could be diverted from the rivers and further inland by operating small perennial canals for the irrigation of parks and gardens.

The most spectacular achievement in utilization of river water in the Indus Plains took place from about the middle of the 19th century with the development of an intricate system of water control and distribution which has led to one of the largest irrigation systems in the world. A permanent barrage was constructed in 1859 on river Ravi, tributary of the river Indus, which made it possible to divert water from the river at all stages of flow and round the year. Following this successful attempt, several barrages have been constructed at strategic points across the river Indus and its major tributaries and, together with a system of link canals, 70 to 75 per cent of the natural river flows are being utilized.

The present irrigation network comprises some 61,000 km. of conveyance channels (canals, branches, distributaries and minors) in 42 principal canal systems which have more than 78,000 water courses (farm channels). In addition, some 600 km. of link canals of very large size have also been constructed. There are now 17 barrages and canal diversion works in the Indus River System. The combined diversion capacity of the main canals systems is nearly 7,080 cu.m./Sec. (250,000 cusecs) with individual capacities up to 439 cu.m./Sec. (15,500 cusecs). The diversions are generally limited in the high flow season (summer) by the capacity of the canal system and in the low flow season (winter) by the available water supply.

The gross area commanded by the irrigation system (within the Indus Plains) totals about 16.3 million ha. of which about 14.0 million ha. are classified as culturable – some 8.9 million ha. of this area are perennially supplied while the remaining receives non-perenial supplies usually from mid-april to mid-October. Presently about $1.23 \times 10^{11} m^3$ of river flows are diverted out of which about $7.16 \times 10^{10} m^3$ are available at the heads of water courses.

Drainage : Prior to the advent of canal irrigation in the Indus Plains, run-off from monsoon storms found its way to natural channels and then eventually entered the rivers. When the canals were constructed they intercepted run-off and increased flood hazards. Surface drainage works, therefore,

Table 3. Gross National Product (GNP) and Per Capita Income at Constant Factor Cost of 1959-60

Year	Gross national product (GNP) (Rupees in million)	Contribution of agriculture section to GNP per cent	Growth of GNP (Per cent)	Per capita income (Rupees)	Growth rate of per capita income (per cent)
1959-60	16,803	45.9	0.8	373	–1.6
1960-61	17,624	43.7	4.9	381	2.1
1961-62	18,683	43.7	6.0	393	3.1
1962-63	20,008	43.0	7.1	409	4.1
1963-64	21,322	41.3	6.6	424	3.7
1964-65	23,299	39.8	9.3	450	6.1
1965-66	25,079	37.1	7.6	471	4.7
1966-67	25,853	38.0	3.1	472	0.2
1967-68	27,636	39.7	6.9	490	3.8
1968-69	29,425	39.0	6.5	507	3.5
1969-70	32,338	38.9	9.9	542	6.9
1970-71	32,362	37.7	0.1	526	–3.0
1971-72	32,883	38.4	1.6	519	–1.3
1972-73	35,360	36.3	7.5	542	4.4
1973-74	38,085	35.1	7.7	567	4.6
1974-75	39,651	33.0	4.1	573	1.1
1975-76	41,410	33.0	4.4	581	1.4
1976-77	43,022	32.5	3.9	586	0.9
1977-78	47,305	30.3	10.0	625	6.7
1978-79 (P)	50,304	29.7	6.3	646	3.4
1979-80 (P)	53,193	29.8	5.7	663	2.6

Source : Government of Pakistan, Pakistan Economic Survey, 1979-80, Finance Division, Economic Advisor's Wing, Islamabad, p.p. 10, 11, Satistical Annexures 1980.

become necessary to protect the agricultural lands from the effects of excess storm water run-off and flooding. At present, there exists a large network of surface drains in the irrigated areas of the Upper Indus Plains and to a lesser extent in the Lower Indus Plains.

The existing surface drains suffer from several problems, the major one being the inadequate maintenance facilities. During winter, the flow in the drains decreases considerably so that fungus formation appears on the surface of the water and obstructs its flow. Very often weeds also grow in the bed and sides of drains.

Continued seepage from conveyance channels in the absence of efficient drainage system resulted in gradual rise of the water table, creating waterlogging and soil salinization problem. Large-scale efforts to control and eradicate this problem were started by the Government in 1958, under the Salinity Control and Reclamation Project (SCARPs) Programme. This work has been assigned to the Water and Power Development Authority (WAPDA). For sub-surface drainage in the affected areas, vertical drainage has been provided in the plains in those areas where tubewells are feasible. In other areas, horizontal drainage projects have been proposed. So far about 13,400 tubewells have been installed in the public sector under the above programme. In addition, some 146,000 tubewells of relatively smaller capacity in the private sector are also indirectly providing sub-surface drainage.

Economy

The country being a developing one has a fluctuating economic growth rate. The values of Gross National Product and per capita income at constant factor cost of 1959-60 are given in Table 3.

Though there has been a continuous increase in Gross National Product (GNP), the increase in per capita gross income has been insignificant due to the increase in population. The country has to take big strides to stabilize the economy and attain autarky in food. Presently efforts are under way both in the public and private sectors to start another and more lasting 'green revolution'.

DESERTIFICATION PROBLEMS IN PAKISTAN

Pakistan is confronted with various kinds of desertification problems which are causing damage to the productive soils. The areas in the arid and semi-arid regions where desertification is active in one form or another are: barani (rain-fed) areas, rolling sandy areas, flood spill areas and the irrigated areas. Desertification is also active in the sub-mountainous regions in the western and northern parts of the country which form the watersheds of the Indus River System where, owing to the damage to the vegetal cover due to excessive and widespread removal of the woody vegetation and heavy overgrazing, soil erosion has accelerated. In the following paragraphs discussion will, however, be restricted to the desertification problems in the semi-arid and arid regions of the country in general and soil salinization and waterlogging in particular.

Barani (Rain-fed) Areas

Agriculturally, barani tracts of Pakistan are the most important areas next to irrigated plains. About 5.7 million ha. in these areas are under cultivation which is about one-third of the total cultivated area in the country. Water and wind erosion is, however, a big problem in these areas limiting agricultural production. Water erosion is the problem affecting agricultural productivity mostly in the northern uplands while wind erosion has led to desertification of vast areas in the southern region. Due to water erosion millions of tons of fertile top soil are getting washed away. The shifting of sand dunes due to wind storms damages crops, chokes up waterways and blows away fine particles of sand leaving behind infertile sandy wastes. These areas present a stunning picture of sheet and gully erosion.

Agriculture is being managed in these areas at extremely primitive levels of technology and is wholly dependent on rainfall, the pattern and distribution of which does not meet the crop requirements. The population explosion in these areas has caused the crop area per person to dwindle and the holdings are fragmented. These constraints have caused serious set-back to agricultural development. There are, however, bright prospects to secure substantial increase in agricultural production through better and improved agricultural management technology.

Rolling Sandy Areas.

Considerable part of Pakistan is occupied by wind re-worked sand. The notable rolling sandy areas are Cholistan and Thal Doab in the Punjab, and Thar in Sind. Other similar desert areas are Dera Ismail Khan in the North Western Frontier Province and the Kharan in Baluchistan. The surface relief of these areas generally comprises longitudinal, transverse and alveolar dune form. The sub-soil water over most of the area is brackish and is unfit for agriculture and for human or livestock consumption. The average annual rainfall varies from about 80 to 200 mm. The rainfall is collected in ponds to sustain livestock for a short period and on its drying up the livestock is moved to settled areas. The people live in small hamlets and their main profession is livestock grazing. Although the potential of rangelands in these areas is extremely low it is possible to increase forage production through proper management. This is receiving due attention of the Government.

Sailaba (Flood Spill) Areas

After the Indus Waters Treaty of 1960 with India under which India was given the right to use waters of the three eastern tributaries of the river Indus, agriculture in sailaba (flood spill) areas extending about 1.2 million ha. has been seriously affected. Appropriate measures to combat desertification in these areas and to increase agricultural prospects are being looked into.

Irrigated Areas

The irrigated areas of the Indus Plains, which once used to be the granary of the sub-continent, are the hardest hit areas of Pakistan due to desertification by soil salinization and waterlogging. Notwithstanding the factors conductive to increased and sustained agricultural production in these areas, the yields are at present among the lowest in the world which can be attributed to a great extent to the above problem caused by extensive development of irrigation and unscientific irrigation practices over the years. The soil salinization and waterlogging problem and its extent, the remedial measures adopted and their impact, and the research and extension in this field and related aspects are dealt with below:

The Problem and Extent : Before the introduction of weir controlled irrigation system in the Indus Plains, the lands adjacent to the rivers were being irrigated through inundation canals. The water table was fairly deep over most of the area except near the confluences of the rivers and under narrow marginal plains along the river courses that were flooded each year during the monsoons. The infiltration of water from the rivers and the deep percolation of rainfall and the water applied in the seasonal inundation irrigation within any particular area was in equilibrium with the discharge of ground water by evapotranspiration and by movement out of the area towards the sea. As soon as the perennial canal system was introduced, the dynamic equilibrium between the ground water recharge and discharge was disturbed. The deep percolation of water from canals and irrigated lands formed a new increment of recharge which was greater than the rate at which water could be discharged from the aquifer. As a result, water tables rose in the canal irrigated areas. Over large areas of the Northern Zone water tables rose at rates varying from about 0.04 m. up to 0.7 m. or more per year. In the Southern Zone, the rate of rise was not so rapid but neither did the previous water table lie at such great depths because of the low altitude and nearness to the sea. As a consequence, water table had risen, as early as the late 1930s and early 1940s over most of the irrigated areas, in both the Northern and Southern Zones of the Indus Plains to within 3 m. to 4.5 m. In areas where the water table came very close to the surface, creating waterlogged conditions the drainage capacity of the soils was reduced, affecting the agricultural productivity of the soils. Further, greater evaporation for the high water table resulted in a steady accumulation of salts in the upper horizons of the soils. In these areas where application of irrigation water was insufficient to leach down salts, an environment was created which accelerated the salinization of land and the water table approached the land surface. As the water table continued to rise in the irrigated areas more and more land became adversely affected and went out of production.

As of March 1980, out of a surveyed gross commanded area of about 16.3 million ha., severely waterlogged (water table 0-1.5 m.) and moderately waterlogged area (water table 1.5-3 m.) constituted 1.3 and 4.7 million ha. respectively. As a result of the surface salinity survey carried out on 16.7 million ha., the areas under slightly saline, moderately saline and highly saline soils formed about 1.76, 0.96 and 1.31 million ha. (Appendix II). The soil surveys of the irrigated areas in the Indus Plain showed about 4.5 million ha. are presently salt affected out of which 0.6 million ha. are considered to be due to canal irrigation and the rest as geologic, created by soil forming processes a few thousand year ago.

Remedial Measures : The problem of waterlogging and salinity has been engaging attention from as early as 1917. Early measures included frequent and extensive canal closures, lowering of canal water levels, conversion of perennial to non-perennial irrigation, lining of channels, planting of eucalyptus groves, reclamation by rice cultivation and use of open surface drains and a few tubewells. None of these measures was extensively applied or intensively pursued; hence little in the way of tangible results was achieved. The tremendous extent of the problem required comprehensive investigations on an extensive scale which were started in 1954 in the Upper Indus Plain. These investigations were later extended to cover the entire canal irrigated area in the country so as to evaluate the problem in the overall context and to evolve feasible means and methods for the ultimate solution of the problem. The programme of investigation included soil and salinity surveys; compilation and analysis of ground water data; drilling of test holes and electric logging to study sub-surface geologic conditions; pumping tests for determining the aquifer characteristics; collection of ground water samples from varying depths and their chemical analyses; seepage studies from rivers and canals; etc.

The planning of the first major Salinity Control and Reclamation Project (SCARP) was completed in 1958. In 1961, a ten-year programme of Waterlogging and Salinity Control was formulated which recognized the need for development of useable ground water for providing sub-surface drainage and for supplemental irrigation to increase the agricultural production. Subsequent to the formulation of the above programme and its review by a panel of experts from the USA, the planning studies were further intensified and a Master Plan for the whole area and Regional Plans for Southern and Northern Zones were prepared. These were reviewed by a Study Group of the World Bank who also compiled a comprehensive report on the water and power resources of the country and recommended a ten-year action programme to increase the agricultural production. This programme recommended undertaking of public tubewell projects in areas which were predominantly underlain by fresh ground water and where reclamation problem was not very severe but excluded areas where conditions were most favourable to continued rapid growth of private tubewells. The programme gave great importance to some of the surface drainage works especially the Sukh Beas Nallah Drainage Scheme and the Lower Indus Left Bank Outfall Drain. In addition recommendations were made for canal remodelling and also tile drainage projects.

Waterlogging and Salinity got added impetus in 1973 when, on the directive of the Government, an Accelerated Programme of Waterlogging and Salinity Control was prepared. This programme, more or less, follows the recommendations contained in the Action Programme proposed by the World Bank Study Group.

Upon the implementation of the programme, it would be possible to cover a CCA* of about 5.7 million ha, during the period 1974-1975 to 1984-1985. This would still leave an area of about 5.3 million ha. from which the menace would be eradicated over a further period of 15 to 20 years after 1985. The Accelerated Programme is being reviewed to change the relative priorities of some projects in the light of the latest conditions of waterlogging and salinity and to update the cost estimates in view of the latest inflation. According to the present proposals, the whole of the remaining area of over 8.9 million ha. which has not been tackled so far, is scheduled to be covered in a period of 21 years. It is estimated that the programme would involve the construction of about 37,921 new tubewells, replacement/rehabilitation of 21,095 tubewells, construction of about 15,829 km. surface drains, 59, 806 km. of tile drains and remodelling of 1,050 km. of existing surface drains.

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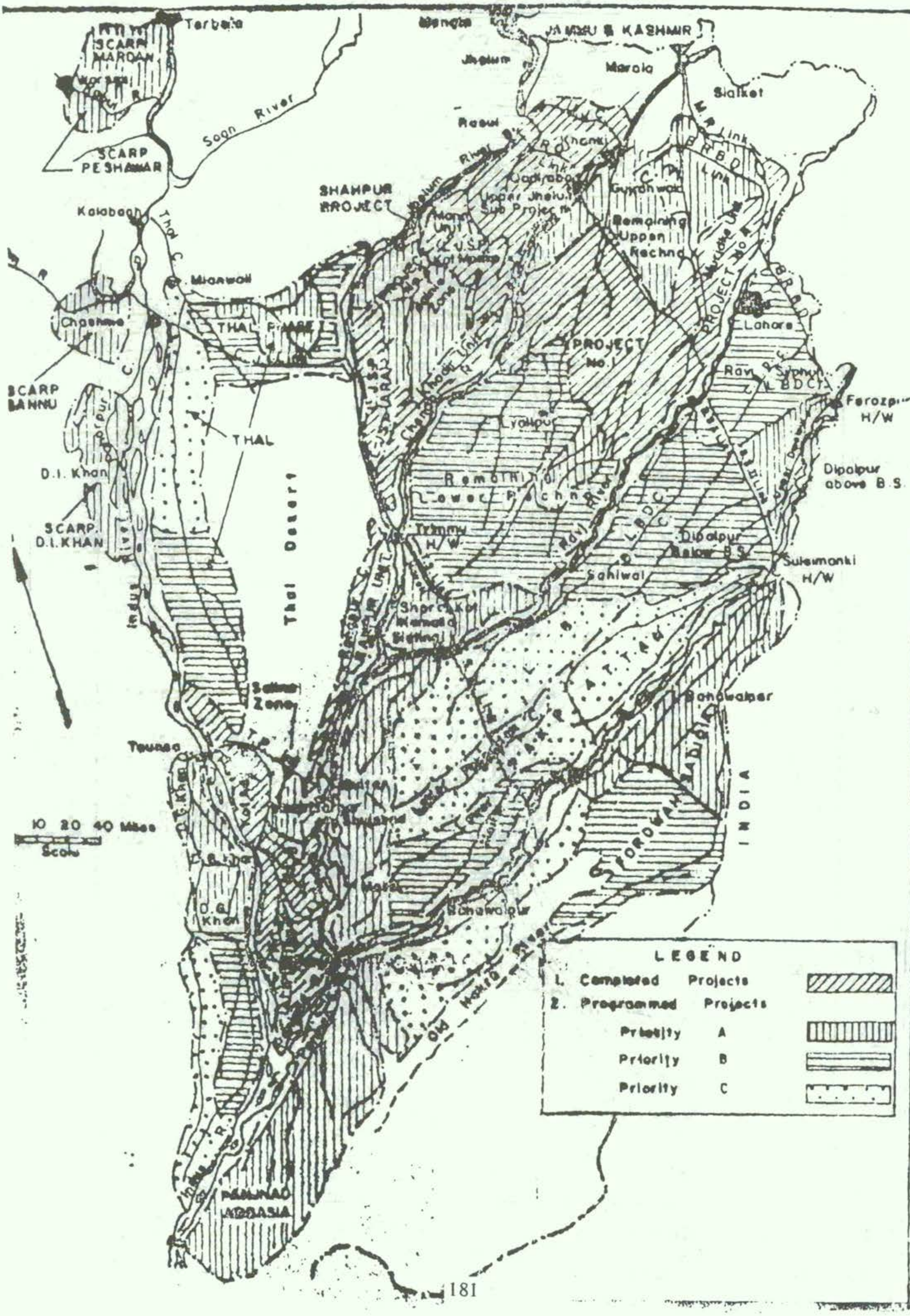
* Culturable Commanded Area is the culturable area within a canal system which can be irrigated by gravity flow from canal system.


Terbela
SCARP MARDAN
JAMMU & KASHMIR
Jhelum
Marala
Sialkot
Soan River
Rasul
SCARP PESHAWAR
SHAHPUR PROJECT
Kalabagh
Thal C.
Mianwali
Remaining Upper Rechna
THAL
PROJECT No.1
Lahore
SCARP BANNU
Lyallpur
Ferozpur H/W
D.I. Khan
Dipalpur above B.S.
SCARP. D.I.KHAN
Thal Desert
Lower Rechna
Trimmu H/W
Dipalpur Below B.S.
Sahiwal
Sulemanki H/W
Indus
Bahawalpur
Taunsa
10 20 40 Miles
Scale
INDIA
D.G. Khan
Old Hakra River
LEGEND
1. Completed Projects
2. Programmed Projects
Priority A
Priority B
Priority C

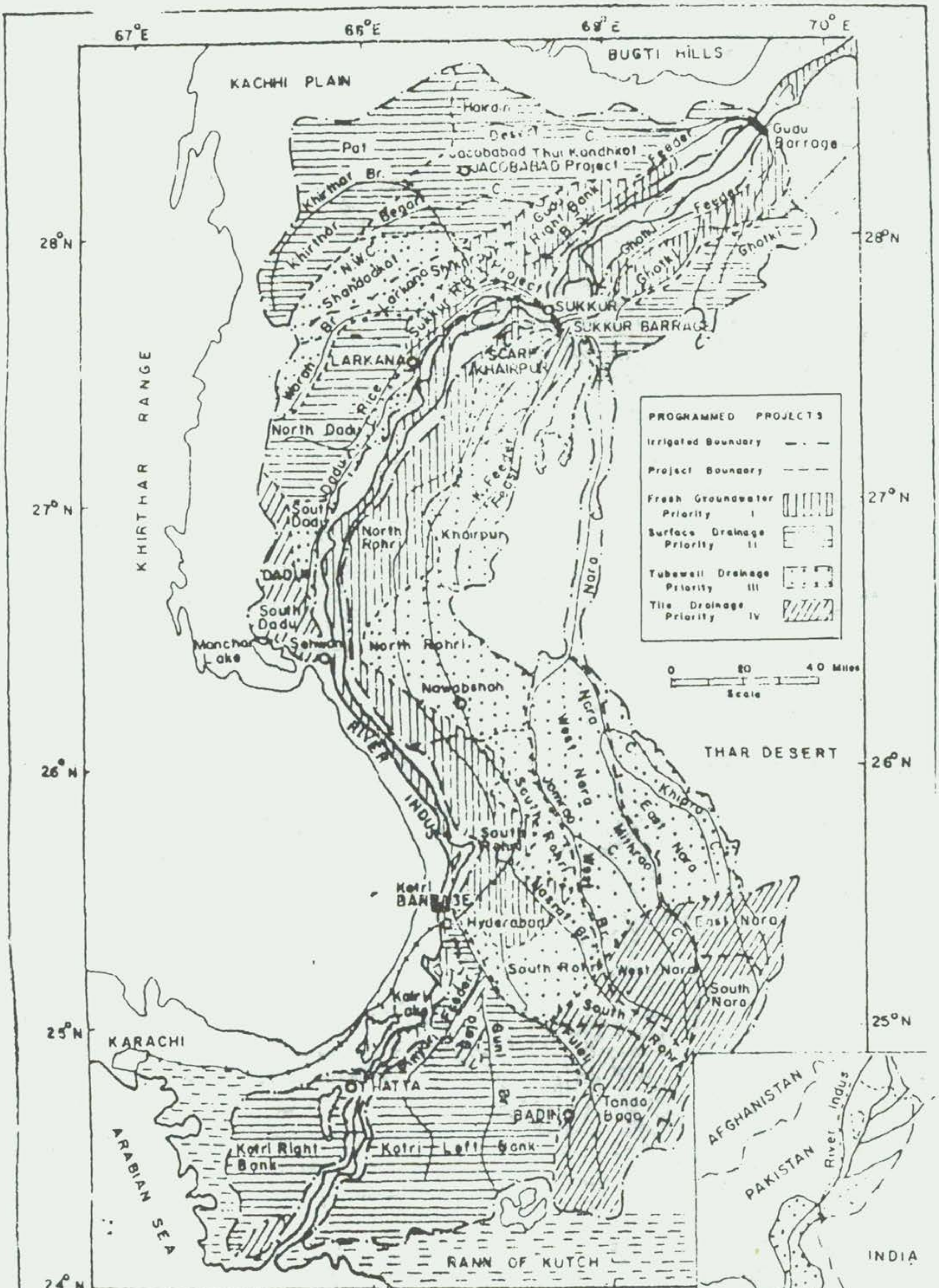


Fig.3 — WATER LOGGING AND SALINITY CONTROL PROJECTS IN SOUTHERN ZONE

Impact of Drainage and Reclamation Projects : The results of the implementation of the Salinity Control and Reclamation Projects are promising particularly with respect to drainage aspects inspite of the problems of corrosion and incrustation in tubewells. In Salinity Control and Reclamation Project No. 1 which has been in operation for the past 18 years, the water table is now between 3 to 6 m. below land surface thus eliminating waterlogged conditions. Reclamation of about 45 per cent of the saline area has also been achieved; however, amelioration of saline-sodic or sodic soils has been very slow.

As a result of land drainage, reclamation of considerable salt affected area and availability of increased irrigation supplies through ground water pumpage by tubewells together with additional agricultural inputs such as fertilizers, good quality seeds, better agronomic practices etc., the cropping intensities have gradually increased and the crop yields have improved. Consequently, the gross value of the agricultural produce (crop and livestock) in the project area has increased 2.5 times compared with the pre-project conditions.

Ground water pumpage and its use has, however, created some problems. Monitoring studies have indicated that the deterioration in ground water quality is, at places, more than what had been anticipated at the time of planning. The deterioration in water quality has been attributed to varying changes in ground water environment by reasons of extensive ground water development and its uses.

It has also been reported that the use of tubewell waters has, in some cases, caused adverse changes in chemical characteristics of the soils. Due to the use of high sodium and bicarbonate waters, the problem of sodicity has developed in some areas where the soils were originally salt free. In such areas the farmers have of necessity changed the pattern of agriculture; the area under sensitive cash crops has declined.

Research and Extension

Research : There are several institutions in the country which are interesting themselves in research studies in the fields of irrigation, drainage, reclamation and water management practices. The prominent institutions among them are:

i) Irrigation Research Institute, the Punjab
ii) Directorate of Land Reclamation, the Punjab
iii) Mona Reclamation Experimental Project, Water and Power Development Authority
iv) Irrigation, Drainage and Flood Control Research Council
v) Agricultural Research Council
vi) Agricultural Universities and Research Institutes

The Irrigation Research Institute, has been conducting research since 1924 in hydraulics, irrigation, drainage and reclamation etc. Research on problems relating to reclamation of saline and sodic soils, consumptive use of water, irrigation practices, etc. is being carried out in the Directorate of Land Reclamation, Government of the Punjab. The work at Mona Reclamation Experimental Project (MREP) includes research on the effective use of water and land, the reclamation of saline lands and agricultural development. The Irrigation, Drainage and Flood Control Research (IDPCR) Council organizes, promotes, co-ordinates and conducts research in the fields of irrigation, drainage, hydraulics, tubewells, reclamation and flood control etc. The Council has set up a national institute called Drainage and Reclamation Institute of Pakistan (DRIP) for conducting research in the fields of drainage of agricultural lands; salinity control and land reclamation; water use and management; and, economic and technical evaluation of drainage and reclamation methods.

The Agricultural Research Council, the University of Agriculture Faisalabad, and the provincial Agricultural Research Institutes which concentrate mostly on agricultural subjects are also conducting research on irrigation water requirements of crops, farm water management, etc. The Agricultural Research Council has also established a national institute for Arid Zone Research.

Extension : The Agricultural extension service is available in the related organizations. Through the extension workers, efforts are being made to convey the research findings to the cultivators. Modern irrigation practices are being taught by laying out demonstration plots, both on the land of the cultivators and at the experimental farms of various organizations. However, there is a great need to improve the extension service programme both qualitatively and quantitatively.

For producing trained extension workers from the public and private sectors, the University of Agriculture, Faisalabad has started a programme called the Farm Guide Movement in which persons from all walks of life interested in social work participate voluntarily. The subjects of training include crop production under irrigated conditions, plant protection, livestock management, community development, adult education, civil defence and first aid. Facilities also exist for training by correspondence in different trades and professions.

Appendix I

LAND UTILIZATION

Area in '000' hectares

Year	Total area	Area not reported	Area Reported		
			Forest area	Not available for cultivation	Other uncultivated and excluding current fallows
1967-68	79,608	26,445	2,282	18,874	12,582
1968-69	79,608	26,660	1,874	20,533	11,250
1968-70	79,608	26,680	1,841	20,396	11,457
1970-71	79,608	26,057	2,833	20,400	11,108
1971-72	79,608	26,114	2,719	20,436	11,254
1972-73	79,608	25,859	2,816	20,724	11,088
1973-74	79,608	25,701	2,853	20,525	11,149
1974-75	79,608	25,688	2,800	20,320	11,250
1975-76	79,608	25,688	2,840	20,630	10,620
1976-77	79,608	25,598	2,850	20,600	10,800

Area Reported

	Cultivated Area					Total area report
	Current fallows	Net area sown	Total area cultivated	Area sown more than once	Total cropped area	
1967-68	4,549	14,876	19,425	2,064	16,940	53,163
1968-69	5,042	14,249	19,291	1,987	16,236	52,948
1969-70	4,698	14,536	19,234	2,238	16,774	52,928
1970-71	4,771	14,439	19,210	2,181	16,620	53,551
1971-72	4,751	14,334	19,085	2,262	16,596	53,494
1972-73	5,046	14,075	19,121	2,865	16,940	53,749
1973-74	4,184	15,196	19,380	3,092	18,288	53,907
1974-75	4,780	14,770	19,550	2,600	17,370	53,920
1975-76	4,770	15,060	19,830	2,960	18,020	53,920
1976-77	4,720	15,040	19,760	3,060	18,130	54,010

Source : Pakistan Statistical Yearbook 1973, Statistics Division, Government of Pakistan, Food and Agriculture Wing, Planning Unit, p. 28.

Appendix II

Extent of Waterlogging and Salinity in Pakistan

A. Waterlogging (million ha.)

Provision	Gross commanded area	Area Affected			Source
		Severely (water table at 0.1.5. m)	Moderately (water table at 1.5-3 m)	Total	
Punjab	9.96	0.58	2.43	3.02	Central Monitoring Organization, Water and Power Development Authority
Sind	5.84	0.71	2.28	2.98	Lower Indus Project Report 1960
NWFP	0.49	0.04	0.004	0.04	Director, Land Reclamation
Baluchistan	–	–	–	–	
Total	16.29	1.33	4.71	6.04	

B. Salinity

Province-wise Summary of Soil Salinity/Alkalinity Classes (million ha.)

Province	Slightly saline	Moderately saline	Highly saline	Total
Punjab	0.71	0.40	0.30	1.41
Sind and Baluchistan	1.00	0.55	1.00	2.55
Frontier	0.05	0.01	0.01	0.07
Total	1.76	0.96	1.31	4.03

Appendix III

Brief Note on the Developments Since the U.N. Conference on Desertification Held at Nairobi in 1977

A brief resume of the developments in Pakistan to combat desertification processes following the U.N. Conference on Desertification held at Nairobi in August-September 1977 is given below:

Water and Power Development Authority (WAPDA)

Waterlogging and soil salinization, the main causes of desertification in the irrigated areas of the country occupying about 34 million acres (14 million hectares) continued receiving the Federal Government's highest consideration during this period. Efforts to control and eradicate the problem are being carried out under the Water Sector Development Programme by the agency assigned by the Government to carry out the work viz. the Water and Power Development Authority (WAPDA).

For drainage in the waterlogged lands, installation of tubewells was continued both in the northern and southern zones of the Indus Plains. In the northern zone 1,704 tubewells constructed in the Punjab and 245 in the North Western Frontier Province were commissioned since July 1977. Similarly in the southern zone 625 tubewells constructed in various parts were commissioned. These tubewells would provide relief to about 400,000 acres (161,000 hectares) of diseased land. During this period work on a tile drainage project, the first of its kind in Pakistan, covering an area of 40,000 acres (16,000 hectares) in East Khairpur in the southern zone has also been started. For exporting drainage effluent from the southern areas of the Indus Plains work on the construction of an efficient surface drainage system parallel to the river Indus is in progress. This drain called Left Bank Outfall Drain (LBOD) in primarily intended for disposal of effluent from sub-surface drainage in unusable ground water areas totalling 3.68 million acres (1.49 million hectares) into the sea.

In this period, WAPDA's Master Planning Division has revised the Action Plan formulated earlier to tackle the waterlogging problems for maximizing agricultural production in irrigated areas. Planning of new drainage and reclamation projects is now being undertaken within the framework of this Revised Action Plan. The present approach is to encourage the private sector to invest in development of tubewells in the fresh ground water zones and limit Government activity, as far as possible, to saline ground water areas.

To conserve irrigation water losses for making them available to crops, special experimental studies were undertaken by WAPDA in various parts of the country. Considerable amount of water is lost by seepage in the conveyance system from the canal head to the farm, the major loss occuring in the water courses; this is one of the main causes of waterlogging and salinity in irrigated areas. Inexpensive strategies are, therefore, being developed to control this situation.

Radical changes are also being considered by WAPDA in the canal regulation system to meet the crop water requirements as and when needed. Such modifications would require heavy expenditure but a start is possible at the water course level by developing a suitable cropping pattern. Besides, unevenness of the farms and faulty irrigation practices adopted by farmers are also major factors contributing to irrigation water loss for which serious consideration is being given.

Irrigation, Drainage and Flood Control Research (IDFCR) Council

In view of the urgency of research in the fields of land drainage and reclamation, the Irrigation, Drainage and Flood Control Research (IDFCR) Council established the Drainage and Reclamation Institute of Pakistan (DRIP) in 1975 for research on drainage of agricultural lands; ground water management and control; soil salinization; reclamation and management; evaluation of different methods of drainage and reclamation etc. The Institute also documents research on results obtained elsewhere in the world on problems similar to those of Pakistan agriculture and disseminates effectively research results for application by prospective users in the various fields.

Presently the Institute, is concentrating on research on tile drainage. A pilot tile drainage project in the East Khairpur area in Lower Indus Plains has been selected for studies within the main Tile Drainage Project being undertaken by WAPDA.

Soil and Water Management Studies have also been sponsored by the IDFCR Council in the northern and southern zones, while lysimeters have already been constructed in the Punjab; their construction in Sind is in progress.

Agency for Barani Area Development (ABAD)

The provincial Government of the Punjab is giving priority consideration to the development of barani areas (rain-fed areas) in the northern areas of the country. An Agency for Barani Areas Development (ABAD) has been formed with the following functions:

- Planning the uplift of barani areas and to execute specific development projects.
- Co-ordinating the work/operations of nation building departments in barani areas.
- Monitoring and evaluating the progress of development schemes in barani areas.
- Reviewing the progress of different sectors in accordance with Government policies and with reference to recommendations made in the report of Barani Commission 1976.
- Co-ordinating efforts of Government departments in implementing the recommendations of Barani Commission and execution of development projects.
- Reviewing on-going projects and suggesting modifications and improvements and re-allocation of priorities for funds allocation for the development of barani areas.

The main projects/programmes initiated during this period are:

i) Development of horticulture in Murree, Kahuta and other barani areas.

ii) Control of Coddling Moth in Murree Hills.

iii) Construction of mini dams and soil conservation on sub-catchment area basis.

iv) Land leveling and development of water courses for utilization of water in existing small dams.

v) Establishment of Barani Agriculture Training Institute for the training of field assistants.

vi) Installation of tubewells in hard strata in barani areas.

vii) Water disposal outlets improved cultural and agronomic practices.

viii) Reclamation of eroded land.

ix) Range improvement afforestation coverage of badly eroded common land with soil binding species and check damming.

x) Improvement of ponds.

xi) Gully plugging to stablize cultivated land in gullies.

xii) Introduction of fractional technology through 12 H.P. Chinese Power Tillers.

xiii) Intensification of Rural Development Programme for barani areas.

xiv) Para-veterinary training programme for barani areas.

xv) Technical training programme for barani areas.

xvi) Establishment of mechanically cultivated and co-operatively managed hundred acre (40 hectares) farm.

Seminars/symposia were organized to consider ways and means to develop the barani tracts and remove the major constraints for agricultural development. Wheat harvesting and management, development of sub-soil water resources and construction of small water storage reservoirs (mini dams) were the main topics discussed. Efforts were also continued to improve the livestock potential in the sandy areas of Cholistan and Thal Doab.

Similar activities, as in the Punjab, are also being undertaken in the barani areas of other provinces. In Sind livestock development has been given added impetus in the Thar Desert by the Provincial Government. In Baluchistan a programme for the reclamation of wind eroded land and stabilization of sand dunes by raising vegetative cover upon them in shelter belt form in such a way that plants could establish upon bare dunes has been started and considerable progress achieved. In NWFP, control of hill torrents is being given importance and strategies are being developed to utilize this source of water for gainful purposes. Proper management of catchment areas of these torrents is also getting the attention of the authorities.

Pakistan Agricultural Research Council, Universities, etc.

Pakistan Agricultural Research Council (PARC) the provincial Agriculture Research Institute of Faisalabad and Tandojam and Agriculture Universities continued research efforts for increasing agricultural production with emphasis on wheat crop. The Agriculture Universities are also under-taking socio-economic surveys of agricultural areas and are persuing a programme of extension services for the benefit of farmers. These include deeper studies of the reasons for migration of the farming community to urban lands, inheritance laws, land holdings and present irrigation and agricultural practices. Appropriate technologies are also being developed by Appropriate Technology Development Organization (ATDO) for utilizing animal refuse in rural areas as biogas fuel, development of low-cost housing, small self-made electrical plants and sub-soil irrigation with the help of local materials. A National Seminar on Land and Water Resources Development of Barani (rain-fed) Areas was organized by the Centre of Excellence in Water Resources Engineering, University of Engineering and Technology, Lahore in July 1979 wherein general recommendations were made for the policy makers, planning, implementing and research agencies to utilize the resources of barani areas efficiently.

Pakistan National Committee on Desertification

The Pakistan National Committee on Desertification (PNCOD) discussed the Plan of Action approved by the United Nations Conference on Desertification and formed a Standing Experts Croup to assist the PNCOD to (i) review the Report of the Transnational Project for monitoring desertification processes and natural resources in South-West Asia Region and suggest changes, if any, to enhance the effectiveness of the Transnational Project; (ii) review the Plan of Action and draw up a programme for implementation of the Plan covering all aspects – administration, technical matters, creation of public awareness, development of data base, etc. and (iii) advise the National Committee on the implementation of the programme of the Transnational Project.

The Standing Experts Group discussed and approved guidelines for the preparation of a scheme for monitoring desertification processes and natural resources in the pilot project area of Thal lying between the Indus and Jhelum/Chenab rivers. The scheme was accordingly prepared and submitted to Government for approval but in the meantime due to changed political situation in the region, UNEP authorities advised, through their visiting expert Dr. N.D. Gwynne, that the project be modified to restrict the activity to the national level. A smaller scheme 'Pakistan Desertification and Monitoring Unit (PADMU)' has now been prepared and is being processed for approval of the Government. The scheme envisages to monitor desertification processes and natural resources in the Thal Doab area by means of remote sensing techniques, aerial photo interpretation and ground investigations under the guidance of United Nations Environmental Programme-Desertification Combat Unit. The study would cover the following attributes:

a) *Vegetation*

- To map and monitor changes in types, species, productivity, vulnerability and use.
- To assess potential productivity.
- To suggest areas for rehabilitation or improvement.

b) *Soil*

- To map and monitor changes in physical and chemical characteristics of soils and their limitations/hazards.

c) *Soil Moisture*

- To map and monitor occurrence of soil moisture stored near surface and relate it to potential for rehabilitation of areas subject to desertification.

PHILIPPINES

Status and Strategies to Combat Desertification in the Philippines

by

Ed. B. Pantastico & Ma. F.D. Tiamzon*

The reported climate-related disasters in the early seventies such as the droughts in Sahel and Ethiopia, failure of the Indian monsoon in successive years, bad harvests in Russia, floods in Brazil and the Philippines, etc. (Payawal, 1981) were indications of cyclical drop in temperature and precipita tion which may indicate the phenomenon of "desertification" in tropical areas. Thus, desertification is a natural phenomenon; and is being aggravated by man in the quest for food, shelter and clothing.

In the Philippines, the ever increasing pressure posed by population growth makes imperative the optimization of available land and/or expansion through reclamation or development of forested areas and lands left over from industrial exploitation such as mining and logging activities.

With a population of 45 million and a total land area of 30 million hectares, the land area per capita is less than 0.7 ha. The per capita agricultural land is lower than the world average of about 1 ha.

This paper will elaborate on the present agriculture, forestry and industrial activities in the country which may indicate the potential problem of desertification and how the Government is trying to combat the phenomenon.

Geography and Climate

The Philippines is considered a typical tropical rainforest consisting of 7,100 islands and islets with Luzon, Visayas and Mindanao as the largest island groups.

The archipelago is closely scattered within the zone bounded between 21° 25′ north and 4° 23′ north latitude ad between 116° east and 127° east longitude.

The annual precipitation in Luzon, Visayas and Mindanao is 272, 239 and 235 cm, respectively. The island of Mindanao, though having the lowest annual mean precipitation, has a uniform distribution of rainfall throughout the growing season of crops. It is an ideal place for crop production since it is least affected by typhoons.

Most of the islands are climatically influenced by the south-east monsoon which divides the year into well defined wet and dry seasons. The cropping season for annual crops is generally determined by the wet season. Many areas in the country have rain from May to November, the peak being August to September. During the wet periods, typhoons and floods caused by intermittent heavy rainfall are the greatest hazards to crop production in the lowlands.

Forest Situation

As of December 1977, classified forest lands cover 30.9 per cent (9,270,215 ha.) of the total area. Classified forest lands include timberlands, forest reserves, national parks and reservations.

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About 28.6 per cent (8,571,688 ha.) is classified as timberland. Timberland, however, does not necessarily indicate the existence of actual forests since these areas are still in the early stages of reforestation. The regional distribution of forest lands is given in Table 1. Region XI has the largest forest land which is about 43 per cent of the region. Next is Region IX, with 38 per cent of its regional area already declared as forest land.

Table 1 : Land Classification as of December 31, 1977

Region	Regional area	Alienable & disposable classified (Agr'cl. Lands)	Unclassified forest land	Total (classified forest land)	Forest res. & timberland	National park	Classified mil. reserves	Forest land civil reservation
I	2,156,845	906,166	514,741	735,938	662,235	7,281	842	65,580
II	3,640,300	1,014,983	1,397,089	1,228,228	1,226,805	1,011	412	–
III	1,827,785	1,017,538	244,537	565,710	343,930	44,727	116,600	60,453
IV	189,789	108,124	34,848	46,817	41,909	509	564	3,835
IV-A	4,561,525	1,756,557	1,474,194	1,331,654	1,153,176	112,307	3,271	61,137
V	1,763,249	1,207,113	87,711	468,425	443,567	24,858	–	–
VI	2,022,311	1,319,070	257,998	445,243	419,610	25,432	–	201
VII	1,495,142	804,876	292,425	397,841	381,738	16,090	4	9
VIII	2,143,169	950,234	867,024	325,911	323,624	2,111	176	–
IX	1,868,514	859,721	300,212	708,581	701,861	6,674	46	–
X	2,832,774	1,014,711	863,672	954,391	954,334	57	–	–
XI	3,157,966	1,097,788	700,186	1,359,992	1,225,459	74,177	–	60,356
XII	2,340,631	934,885	705,262	701,484	693,440	48	7,996	–
TOTAL	30,000,000	12,990,866	7,738,919	9,270,215	8,571,688	316,092	129,911	252,524

Source of data: Bureau of Forest Development

Soils and Land Capability Classification

Soils in the hilly areas especially on stable uplands are generally strongly weathered and highly leached. They are characterized by low population density. At present economic level, these soils are considered marginal lands or, if not planted to economic crops, they are abandoned and deserted.

Approximately 17,128,000 ha. are potential problem soils. These soils consist of Oxisols (149,000 ha.), Ultisols (16,422,400 ha.) and Andepts (1,164,804 ha.).

Oxisols generally occur in very old stable lands, where weathering products have been protected against erosion during long periods. Natural fertility is generally low due to low pH, low cation exchange capacity, preponderence of low activity clay and low organic matter. Without fertilization, Oxisols can support extensive agriculture only under shifting cultivation or with trees that protect the soil or with extensive grazing. These soils are generally classified as the laterites which are characterized by free sesquioxides and alter the soil into a bad rock.

The Philippine land capability system was patterned after the USDA system with slight modifications to suit Philippine conditions. Table 2 shows that 8.63 per cent of croplands are classified as Class D land, 0.01 per cent and 49.65 per cent of the pasture lands are classified as classes L and M

Table 2 : **Land Capability Classes and Subclasses**

Capability class & sub-classes	**Area**		**Percentage**	
A		1,589,052.45		5.30
Be	618,145.57		2.06	
Bw	1,668,911.64		5.57	
Bs	595,104.24		1.98	
Sub-Total-B		2,882,161.45		9.61
Ce	1,183,024.28		3.94	
Cw	38,181.00		0.13	
Cs	67,758.27		0.23	
Sub-Total-C		1,288,963.55		4.30
De	2,347,100.08		7.82	
Dw	–		–	
Ds	241,385.16		0.81	
Sub-Total-D		2,588,485.24		8.63
Ls	3,810.00		0.01	
Lw	–			–
Sub-Total-L		3,810.00		0.01
M		14,891,202.56		49.65
N		4,178,153.24		13.93
X		614,485.75		2.05
Y		1,955,829.24		6.52
GRAND TOTAL		29,992,143.48	100.00	

lands respectively. Forest lands, which are classified as class N, constitute about 6.52 per cent of the total non-agricultural lands. The definition of the land classification class and sub-classes are described in Annex I. These land classes, based on their characteristics, are usually subjected to area desertification in the case of croplands and forest denudation and in the worst condition, left barren lands in steep forest areas.

In the Philippines, mountains are mostly denuded and are bare of cogonal species. These areas are not confined to moderately sloping terrain. Even areas with very steep slopes are already bare and are regarded as deserted and abandoned lands. An examination of their characteristics shows that, in many places, they are rocky and the original structure of the soils is already disturbed such that the top or fertile soils are already mixed with unfertile horizons. These are evidences of frequent landslides and/or erosion which are attributable to the steep slopes and to the soil texture of deep sandy-loam in most of the deserted areas.

Topographically, about 39 per cent of the country's land area is characterized as hilly to mountainous, rough or rugged. The watershed areas have been covered by forest, however, the increasing pressure of a rapidly expanding population has necessitated the cultivation, exploitation, and destruction of these areas in more recent times.

Agricultural Utilization

The country has about 11.8 million ha. of agricultural land. About 3.55 million ha. (29.97 per

Table 3 : Types of Crops and Areas, Philippines, 1977.

Types of crops	Areas (ha.)	Percentage of the total agricultural area
All crops.	11,836,900	100.00
Food crops	8,152,180	68.87
Palay	3,547,500	29.97
Corn	3,320,600	28.05
Fruits & nuts except citrus	441,070	3.73
Citrus	22,070	0.19
Rootcrops	451,200	3.81
Vegetables except onion & potato	56,170	0.47
Onion	11,590	0.10
Ginger	4,830	0.04
Irish Potato	3,030	0.026
Beans and peas	62,820	0.53
Coffee	76,180	0.64
Cacao	4,350	0.04
Peanut (unshelled)	62,720	0.53
Other food crops	88,050	0.74
Commercial crops	3,684,720	31.12
Coconut	2,728,190	23.05
Sugarcane	567,220	4.79
Abaca	250,290	2.11
Tobacco, native	45,210	0.38
Virginia	30,770	0.26
Ramie	210	0.002
Rubber	58,540	0.49
Maguey	2,630	0.02
Kapok (w/seeds)	720	0.006
Cotton (w/seeds)	480	0.004
Castor Bean	460	0.0039

Source of data: Bureau of Agricultural Economics.

cent of the total agricultural land) are planted to palay while 3.32 million ha. (28.05 per cent) are planted to corn and 2.7 ha. (23.05 per cent) are planted to coconut. The rest of the agricultural land is planted to other crops like tobacco, sugarcane, citrus, vegetables, abaca etc. (Table 3).

SOME FACTORS AFFECTING DESERTIFICATION

Population Pressure

In Table 4, note that Southern Luzon is the most thickly populated indicating available labor force for agricultural production, whereas the Cagayan Valley and Southern Mindanao seem deficient in manpower to effect intensive cultivation.

Table 4 : Regional Distribution of Land Resources, Philippines (1976)[a]

Region	Land area	Distribution (per cent)	
		Arable land	Population
Ilocos	2,160	6.3	7.8
Cagayan Valley	3,630	9.1	4.6
Central Luzon	1,830	10.3	10.4
Southern Tagalog	4,770	10.2	23.6[b]
Bicol	1,770	7.3	7.6
Western Visayas	2,010	11.8	9.2
Central Visayas	1,500	6.2	7.9
Eastern Visayas	2,130	5.2	5.9
Western Mindanao	1,860	6.3	5.2
Northern Mindanao	2,820	8.2	5.7
Southern Mindanao	3,180	8.1	6.6
South-western Mindanao	2,340	11.0	5.5
Total:	30,000	100.0	100.0

Notes: [a]From the basic data of the National Economic Development Authority, *Five-Year Development Plan:* CY 1978-1982.
[b]About 12.3 per cent of this resides in the Metro Manila area.

Slash and Burn or Kaingin System

Several factors are attributed to the degradation, denudation and eventual desertification of the country's once forested and cropland areas. Aside from pest and disease occurrence on trees and crops intentional grass and forest fires, destructive logging practices, poor maintenance of forest roads, the greatest spoiler of these valuable lands is the "kaingin" system or the shifting cultivation or the slash and burn farming. This system has been described as a social, political and economic problem in the Philippines. It has been reported that during the past decades the kaingeros (the farmers) have been responsible for the annual destruction of about 50,000 ha. of forest land which costs millions of pesos. The total area destroyed by the kaingeros constitutes 40 per cent of the total forest destruction year after year during the past 10 to 15 years.

As generally practiced in the Philippines, kaingins may be classified into three types. These are based primarily on the amount of vegetation or style of forest trees being cut and burned, and the kind of farmers who activate the kainging system.

1. *The logged-over kaingin* – This type of kaingin is usually made by the lowland peasants. They follow the loggers who indiscriminately or non-selectively cut the marketable timbers in their forest concessions. As the loggers move further, the peasants occupy the cut-over areas. They cut and clear the growing trees and bushes and set them on fire for three to four weeks. Then the kaingin area is ready for planting. It is usually planted to corn or upland rice, root crops and some economic trees.

   As a result of the burning, weeding is not a problem. Most of the viable seeds, grasses and shrubs are also burned. The peasants continue to cultivate the land for about 2-5 years and, thereafter, sell the land to other peasants if they find other available logged-over areas.

2. *Second growth kaingin* – This type of kaingin is a consequence of the first type when abandoned purposely. Second growth type of forest arises and the kaingin farm turns into a grassland covered by cogon grass, wild vines and plants, and dipterocarps. In less eroded areas, this type of forest can be developed within two to five years time and is characterized by thin humus covering the top soil. At this stage, the kaingero again cuts the grass beneath the bushes and young trees and burns the clearing after a few weeks. The fallen timbers shall have rotted during this period and the area is ready for cultivation. The technique is repeated every 2-5 years if the land is cultivated every crop year. This type of kaingin farm is so susceptible to erosion after a period of 5-10 years that even grass will hardly thrive.

3. *Virgin-forest kaingin* – The kaingero employs a "domain theory" in cutting down the huge trees. All the trees are partially cut whether they are located downhill or uphill. Thereafter, the huge trees on the hilltop are completely cut down and allowed to fall on the small trees downhill. This economizes time and effort as trees are cut down at one time. For another reason, the kaingero finds justification to continue the kaingin system.

Of the estimated 50,000 ha. of forest lands destroyed annually by kaingeros during the past decade, about three-fourths is classified as logged-over kaingin system. Some of these areas have been declared by the Bureau of Forest Development (BFD) as alienable and disposable agricultural lands. Thousands of hectares are still classified as forest lands although permanent trees are already absent as a result of the activities of squatter-kaingeros occupying the areas.

Deserted lands are evident in Visayas and Mindanao, where rivers and creeks are flooded heavily during wet months, and rivers are without water during the summer months.

Mining

Other factors that contribute to desertification of lands in the country are mining activities, which more often than not are carried out with minimal provisions for actual implementation of reclamation programmes. Mining in the Philippines has intensified in the last four years. As of 1977, mineral surveys undertaken by both government and private sectors covered 22.3 million ha. or about 74 per cent of the country's total area. Although mining helps the country economically, it also causes deleterious effects on the eco-system. Mining excavation alters the contour of the land and produces high acidity from large quantities of mineralized subsoil and rocks exposed to air and water. This does not only impair the water quality of rivers and waterways but also causes destruction of plants in watersheds. In surface mining or open pit operation, the original vegetation is scraped, destroyed and altered. A tremendous amount of waste, consisting of top soil and mineralized subsoil, is moved and dumped. The abandoned strip-mined areas become unfertile and unproductive and weathering accelerates soil erosion, landslides and denudations. These symptoms of the undesirable by-products of mining activities are already visible in many parts of the country today. Undeniably, the need to restore surface-mined areas is now being felt by both public and private organizations.

POLICIES AND PROGRAMMES TO ALLEVIATE THE SITUATION

Research

A general research approach to utilize barren lands to support food production includes initial soil classification and land resource inventory to determine the economic productivity levels and economic profile of the areas under study. Farming and inter-cropping systems, studies on soil conservation measures and extension strategies for the development of these areas are likewise among the researchable aspects being dwelt on. The planting of perennial tree crops such as fruit trees, coffee and cacao, intensified pasture management, and industrial tree crop planting are given emphasis to alleviate the denudation and desertification of potential areas both for agriculture and forestry. Supportive to all of these, the researchable areas along the socio-economic component include inventory of the protection as well as production of forests, pasture leases, and cultivated areas which include location, magnitude and problem status. Other areas along these lines are profile data of farmers involved in the ill-suited farming practices, description of indigenous technology packages on land-use management for adoption and utilization by the land users to conserve the physical and productive qualities of the barren lands, parameterization studies on watershed management systems, and feasibility studies of alternate forest land uses and management technology packages.

Policies and Action Programmes

The following are the existing policies and programmes of the Philippine government to alleviate, if not totally solve, the existing problems on denudation and desertification of areas with potential for agriculture and forestry purposes.

1. *The Revised Forestry Code of the Philippines*

   This policy does not necessarily mean legalizing the old practices of shifting cultivation but forms an integral part of the forest protection scheme. This is aimed at solving the problem of shifting cultivation by managing the kaingeros under a development programme known as "Kaingin Management," where bonafide kaingeros are granted Forest Occupancy Permits. The forest occupants are assisted in the development/improvement of their farms in order to increase crop production. The actual areas developed or cultivated are inspected, evaluated in order to prevent future expansion of clearings. The kaingeros are also encouraged to practice agro-forestry, orchard plantation, bench terraces, tree farming, and livestock production. Socio-economic activities such as cottage industries, home-crafts, family planning, co-operatives and others are also introduced.

2. *Forest Eco-system Management (ProFEM)*

   The programme is designed and implemented on a holistic eco-system approach. It calls for the total involvement of all government agencies, the private sector, civic and other organizations, and political institutions in the forest renewal activity of the country. It aims to achieve within a five-year period the reforestation of 750,000 ha. of critical watersheds and other open and denuded forest lands, school grounds, military camps and reservations, communal and forest parks. It also aims to beautify the roadsides by planting fruit bearing and ornametal trees along the highways, including provincial and barangay roads. The programme likewise involves the production and proper distribution of about 2.5 billion seedlings of various species of trees and plants of economic value.

3. *Tree Planting Programme*

Every citizen of the country, at least 10 years of age, unless physically disabled, should plant one tree every month for five consecutive years.

4. *The Development of Industrial Tree Plantations and Tree Farms*

This programme helps to accelerate the reforestation effort of the country. It puts the vast uncultivated and idle tracts of land into maximum productive use, as well as increases the total forest stock for future sources of wood and food. It also improves the ecological conditions of degraded deforested region. The minimum area of 1,000 ha. is granted for industrial tree plantation and 100 ha. for tree farm, provided the size of the area shall in each case depend upon the capacity of the leasee to develop or convert into productive condition within the term of the lease and provided further that no lease shall be granted within critical watersheds.

One of the commonly used species for industrial tree plantation and tree farm is the giant ipil-ipil (*Leucaena* sp.). This species is rapidly gaining popularity not only in the Philippines but also in other tropical countries because of its fast growth and economic potential.

5. *The Family Approach Reforestation Programme*

This is a programme that enables families to acquire open lands of approximately 5 ha. where seedlings provided by the Government are planted. The families are required to maintain and protect the established plantations for two years. Agricultural crops are also allowed to be planted as intercrops in their assigned areas. Likewise, these families are being subsidized through payments from the Government on an installment basis. The last installment is paid only when the percentage plantation survival attained is at least 80 per cent.

6. *Maintenance and Protection of Established Plantations*

This programme is carried out through the barangay units to protect the plantations from fire and encroachment.

7. *Philippine Environmental Policy*

The policy is a component of the Environmental Impact Statement to restore, for production purposes, barren lands from industrial exploitation, i.e. mining activities. The policy requires all operators or holders of mining claims and applicants for quarry permits or licenses to submit an initial environmental examination and/or environmental impact statement upon filing of lease applications or prior to issuance of such permits and licenses.

PRESENT AND PROGRAMMED LAND USE

As a result of the government programme, projections were made on the future land-use pattern (Table 5). As projected there will be an increase in National Parks, man-made protection forest, fish ponds and urban areas. No increase was projected for forest range/pasture land, marshes, and mangrove swamps. This indicates that these land areas will be maintained.

Table 5 : Present and Projected (1976 and 1987) Land-Use Pattern (in 1,000 ha.)

Category of land use	1976		1987	
National total	30,000	100%	30,000	100%
1. Total forest land area	17,025	56.3	13,750	45.8
1.1 Production forest	9,756	32.5	8,376	27.9
1.2 Production forest (including National Parks)	1,727	5.8	2,070	6.9
1.3 Man-made protection forest	(239)	(0.8)	923	3.1
1.4 Open land/cultivated*	4,297	14.3	1,138	3.8
1.5 Forest range/pasture land	934	3.1	934	3.1
1.6 Marshes	82	0.3	82	0.3
1.7 Mangrove swamps	228	0.8	228	0.8
2. Total non-forest land area	12,975	43.2	16,250	54.2
2.1 Cropland	7,488	25.0	7,507	25.1
2.2 Fish ponds	176	0.6	229	0.7
2.3 Inland water	231	0.8	231	0.8
2.4 Urban	1,086	3.6	1,400	4.7
2.5 Residual	3,994	13.3	6,863	22.9

SUMMARY AND CONCLUSIONS

The Philippines is considered a typical tropical rainforest. Topographically, about 39 per cent of the country's land area is characterized as hilly to mountainous, rough or rugged. The mountains are mostly denuded and bare of cogon species resulting from some farmers' practices like intentional grass and forest fires, destructive logging activities, slash and burn farming and others. In addition, population pressure and mining activities contribute to desertification of lands.

The government has endeavoured to combat desertification by implementing some policies and action programmes. The general approach in research is to utilize barren lands to support food production. The revised Forestry Code of the Philippines minimizes shifting cultivation by encouraging bonafide kaingeros to practice agro-forestry, tree farming, bench terraces, and livestock production. Likewise, cottage industries and co-operatives are introduced. Other action programmes, like the Forest Eco-system Management and Tree Planting Programme, call for tree planting and production and proper distribution of seedlings of various plants with economic value. The Philippine Environmental Policy was formulated to restore, for production purposes, barren lands resulting from industrial exploitations, e.g. mining activities.

As a result of the government programmes, projections were made on future land-use pattern. There will be an increase in National Parks, man-made protection forest, fish ponds and urban areas, whereas, pasture lands, marshes, and mangrove swamps will be maintained.

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THAILAND

The Implementation of the Plan of Action To Combat Desertification of Thailand

Evaluation of Desertification and Improvement of Land Management

Thailand has a total area of 514,000 sq.km. (51 million ha.) of which one-third is cropland, one-third is forested and the remaining one-third is presently unproductive and uninhabited or is in the urban residential areas. There are four principle regions: The Central flood plain, the North-east plateau, the mountainous North where most of the streams arise, and the peninsular South.

Forest situation: In the last several decades Thailand's formerly abundant forest land has been gradually depleted by local Thai people and nomadic tribes employing slash and burn cultivation. By this particular cultivation method the forest areas are selected, the tribes then cut and burn the vegetative cover to clear the land for temporary cropping without conservation practices. After 4-5 successive years of cropping, fertility in the soil starts to decline. Then they move to the new fertile forest lands and repeat that certain rhythm of slash and burn. This practice has generally been known as shifting cultivation. Since the population growth rate of the country is relatively high, more and more cultivated lands are needed, resulting in forest destruction, creating a national problem. The countrywide survey (1961) showed 56 per cent of the total area was forested; a recent satellite study (1975) indicated that this figure has dropped down to 37 per cent.

With a view to basin management, this transformation does not only depletes the forest resources but also creates ever-growing soil and water management problems. Imperata is the pioneer species that invades the abandoned area after the last season of cropping. The immediate problems from this are the inadequacy of water in the dry season, erosion and flash floods in the rainy season since it is usually burned over during the dry season by both natural and more often man-caused fire. The bare surface soil after burning is very easily eroded by the intense rain of the monsoon season. Tremendous amounts of sediment from this source cause problems with water quality; fish and other aquatic organisms; hydroelectric plants; reservoir management; and the direct environmental effect.

Irrigation situation; Formerly, water resources chiefly put into use were the run-off which prevails in many places, capable of developing at an investment rate cheaper than that of any other resources, for instance, the groundwater and sea water. But due to the fact that the cultivation in recent years has increased to a considerable extent, thereby resulting in a shortage of run-off supply to permit feeding, the plant has to resort to the groundwater available at such places to supplement the supply of water instead. Hence the Groundwater Development has been initiated for the wise utilization of cultivation purpose.

The method for conveying water from the source of supply to the service area for cultivation purpose is to mostly let water gradually flow from a higher to a lower level, capable of permitting irrigation by gravity flow from the source. Such method entails a considerable expenditure, but in turn its cost of operating maintenance is economical, with the exception of certain areas which are not suitable for gravity flow and have to resort to pumping irrigation instead. Besides pumping irrigation on a permanent basis, pump machines have been moving to render aid to crop cultivation outside the irrigated area during the period of rain failure occurring either in the early part or last part of the season and which become the means to serve cultivation purpose in the dry season as well for field crops in the cultivable land.

Land-use situation: Rapid growth of the economy and population in the past has brought tremendous changes in national land-use pattern. In 1977 total farm land was 18.21 million ha. of which about 2.57 million ha. were under irrigation or irrigated area was about 14 per cent of total farm land. The rest is under rain-fed condition. Most soils in Thailand are naturally low fertility. Low soil fertility accompanied with poor technology and rain-fed condition make the agricultural production per unit area of Thai farmers relatively low compared with other countries.

Average yield per unit area of some major crops such as rice decreased from 1.802 ton per ha. in 1969-71 to 1.67 ton per ha. in 1973-75. Desertification process may explain such a change in crop yield.

In addition, deterioration of soil fertility and average crop yields over the years have been caused by serveral factors. New land brought into production is inherently of lower natural fertility. Monoculture of some crops such as maize, sorghum, sugar cane, cassava without the use of fertilizer or with amounts much lower than required, has also tended to accelerate desertification process resulting in reduction of soil fertility and crop yields.

Land is the most important factor in the agricultural production process. Thus the improvement of the living standards of farmers who constitute the majority of the population will require measures for improvement of land management and land utilization.

Thailand lacks a clearly defined national land-use policy as well as a plan. Such issues as timber land versus crop land, reforestation versus annual crops, watershed protection versus shifting cultivation, declining soil productivity, tenants farmers and landless peasants, many farmers without legal tenure, lack of power of eminant domain to force land consolidation or irrigation projects need to be decided.

A number of land-use, soil suitablity or land capability classification and socio-economic studies have been made by the Land Development Department and land use plans have been prepared for specific government projects. The Land Development Department has started to prepare a national land-use plan to be used as a guide for several actions. A national land use law will also be drafted by the Department for review by concerned government agencies.

Furthermore, works on the preparation of land development projects in problem areas, for example in acid sulfate soil areas in Central plain, saline soil areas in Northeast and coastal zones and other desertificated areas, should be accelerated.

Problems in land ownership should be soon resolved. Farmers who lack land tenure are reluctant to make any large capital investments on the land they occupy. Also farmers without valid titles or land-use certificates are unable to secure institutional credits. Furthermore, institutional loans through farmers' organizations tend to be for considerably lesser amount than actually required by individual farmers. To correct this situation the Land Reform Act was passed by the Legislature in 1975 and the Agriculture Land Reform Office was established in the Ministry of Agriculture and Cooperatives. In the past two years, temporary land-use certificates have been distributed to the farmers of about 200,000 ha. of public land. This land will undoubtedly require some land development.

Combination of Industrialization and Urbanization with the Development of Agriculture and Their Effects on Ecology in Arid Areas.

The development of industry, towns etc. cause some extent of ecological change. Planning for zoning of areas for industry, human settlement and so forth should be carefully prepared in order to avoid unequilibrium of ecological system. This should include the recommendation for protection of environmental deterioration.

Base on socio-economic aspect, industrialization and urbanization result in effective use of labour. Traditional farming under rain-fed conditions will utilize farm labour ineffectively especially in the dry season. Industrialization not only improves labour utilization but also increases off-farm income of the farmers. Improvement of farmers' economic status will enable them to make investments in their field.

Corrective Anti-Desertification Measures.

Watershed management

Since the establishment of the watershed management programme under the Royal Forest Department in 1965, the activities listed below have already been undertaken:

1. More than 25,000 sq.km. of watershed areas, which are mainly in the Northern portion of the country, have been surveyed to obtain information on watershed characteristic, topography, and land uses including socio-economic conditions of the basin residents. Data compilation and analysis were carried out as well as workplans for implemention.

2. On the research side, seven watershed research stations in the main basins of the country have already been set up. The research projects focus mostly on the investigation of the watershed characteristics as related to streamflow, basic data collection on hydrometeology, soil, water and plant relationships, and soil erosion control including research on representative and experimental basins. Silvicultural research is another important activity of the programme and studies on proper tree species and nursery and planting techniques for highland plantations are also conducted. Presently, more than 35 research projects are in progress at the watershed research stations around the country.

3. The establishment of 38 Rehabilitation Units and 40 Royal Watershed Development Units has already been carried out since the beginning. These are field operating units on watershed rehabilitation and development. The main tasks are reforestation on headwater areas of denuded watersheds to regulated streamflow regime and the improvement of living conditions of the local residents. Since the beginning of the reforestation programme, up to 1979, a total area of about 360,000 rai (57,600 ha.) have already been planted for watershed protection and about 11,000 rai (1,760 ha.) for village woodlots.

4. For the management of pilot watershed and demonstration projects, a request was made to UNDP/FAO in 1971 for assistance. In 1973, Mae Sa Integrated Watershed and Forest Land Use Project was initiated under co-sponsorship of UNDP/FAO and the Royal Forest Department of the Thai Government as a pilot project. The project area is located in Chiang Mai, northern Thailand. The proposed programme included a forest land-use capability survey, land reallocation, improvement of the cultivation system, crop diversification, yield increases, improvement of road and trail network, land rehabilitation and erosion control measures, improvement of forest stands, reforestation of denuded areas, intensification of forest protection and management, and provision of greater employment opportunities for the local residents through the reforestation activity. The project activities have been carried on for the past seven years, since 1973. A project evaluation in 1976 indicated that this integrated approach was very successful. The Royal Forest Department decided to adopt this programme for management of all the basins in the country.

5. Concerning the development of the hilltribes which are the nomadic group of people living in headwater areas of the northern watershed, the Watershed Management Division started a project called The Hilltribe Resettlement Project in 1977. The activities of the project were attached to the existing reforestation programme in those field units. The project objective was to decrease the rate of shifting cultivation of tribal people by introducing a system of land reallocation, and to stabilize farming among the hilltribe farmers. For this particular project, the proposed project area will be surveyed and classified for land-use purposes into the following çategories:

- All remaining stand of natural forest will be reserved and maintained as such regardless of slope and size.
- All land of greater than 85 per cent slope and the narrow ridge tops will be devoted to watershed protection. All areas in this category will be forested.
- Remaining shifting cultivation area of the basin will be allocated for land-use according to its capability of present and future needs. The allocations are:

1) Household and garden land (less than 35 per cent slope), 0.25 rai/person
2) Agricultural land (less than 35 per cent slope), irrigated 1 rai/person and rainfed 2-3 rai/person
3) Communal grazing land (less than 85 per cent slope), erosion and run-off protected
4) Orchard land (less than 85 per cent slope), erosion and run-off protected
5) Communal woodlot (less than 85 per cent slope)

(NB: 6.25 rai = 1 ha.)

Field operation units will provide technical assistance to the hilltribe farmers through extension work emphasizing soil and water conservation. The development of cropping systems will meet the economic needs of the farmers whilst maintaining soil stability and its nutrient levels. Demonstration plots of local and exotic crops including tea, peaches, coffee, cut flowers, apples, shiitake mushroom and vegetables were introducted. Modifying land forms by installing bench or step terraces were also introduced to the new and existing farms. The hilltribe farmers under the project were also provided with communal grazing land to support their livestock, for this purpose new species of grasses and legumes have been provided. As a part of this aid, a grazing alternative for utilization of plantations in which the planted trees are tall enough to withstand grazing pressure has also been conducted. Establishment of village woodlots is another activity of the project. It will be the source of firewood, lumber, agricultural tools and of other fiber needs. The woodlots will either be natural forest or the plantation of fast growing species. The hilltribe farmers will have ownership of woodlots and will be responsible for their maintainance with the advice of foresters. Roads and trails are the important infrastructure needs for project implementation. It was estimated that more than 800 kms of forest roads have been constructed up to 1979. This part of the work was undertaken by the Engineering Section as well as the construction of small reservoirs which are the source of water for household usage and some irrigation. These reservoirs also serve as the source of fish protein for the hilltribes.

6. Reforestation activity under the watershed management programme also provided employment to the local residents. In 1979, it was estimated that nearly 10,000 persons have engaged in establishing plantations. This employment will provide additional income to the farming families and will secure the living expenses of the resident farmers before their harvesting season.

Water resources development

Water resources development undertaken by Royal Irrigation Department in various forms as completed to the end of 1978 and under construction in 1979 is as follows:

Irrigation, drainage, water conservation, flood control by embankment, and land reclamation have been accomplished over an area of 2,741,429 ha. and out of which 130,800 ha. are entrusted to other official units for operation and maintenance. Work in progress is over an area of 798,085 ha. Of all the works already completed, the most important project of the country is the Greater Chao Phraya Project capable of distributing water to the lower delta of Chao Phraya basin which forms the major part of the Central Plain widely known as the 'Rice Bowl' of the country to an extent of approximately 1,080,000 ha. The greatest project under construction is the Greater Mae Klong Project able to deliver water on the Mae Klong Plain which is on the west of the Central Plain covering an area of 419,500 ha. This project is able to distribute water to an extent of 216,700 ha. The important project initially constructed is the Phitsanulok Project in aid of the cultivable land on one portion of the upper delta of Chao Phraya basin covering 139,500 ha.

Work relating to dike and ditch has been completed on 1,262,023 ha. and is expected to be completed on 11,676 ha. this year while land consolidation has also been completed to an extent of 31,208 ha. with 21,712 ha. expected to be finished in this year.

Pump irrigation for rice cultivation outside irrigated area which is carried out on a yearly basis, benefited an area of 283,618 ha. in 1978.

As regards flood control by storage of water, the reservoirs already completed are capable of storing 28,741 million cubic metres. Two important storage dams, namely Bhumibol Dam on the Ping river and Sirikit Dam on the Nan river both of which are the principal tributaries of the Chao Phraya river, are capable of storing 13,400 million cubic metres and 10,500 million cubic metres respectively. This will help minimize floods over an area of not less than 1,600,000 ha. including highways, railroads, and towns located within the area. The storage of water under construction is expected to contain 1,420 million cubic metres.

Land development programmes

Department of Land Development has set up programmes since it was established in 1963. These include soil survey and national soil maps, land classification, socio-economic survey, land policy and land-use planning, programmes of soil improvement and soil and water conservation and management.

The important basic information concerning soils and land such as land capability etc. have been presented in the reports and maps. These can be exploited in planning of development projects. Land-use planning formulation has been developed at provincial and regional levels. Researches on soil and water conservation, soil improvement and management have been conducted at the 26 Land Development Centres located in different parts of the country.

In addition, services, recommendations and demonstrations in soil and water conservation and soil improvement have been given to an estimated 60,000 farmers with area coverage of about 70,000 ha. per year. This is relatively small scale and it needs to be expanded.

Conservation and development of land resources

There are many instances of agricultural practices which result in excessive soil erosion, accelerated water run-off, decreasing soil fertility etc. Shifting cultivation is a good example. In some case, it does not require conservation as such but rather a good soil management which will help to maintain the productivity of the land farmed. With regards improper land utilization, there are large productive areas in the North-east which are under upland crops. Available information shows that these areas can be converted into pasture.

Besides the construction of soil conservation structures such as terraces, the development of small water resources or construction of farm ponds can be used as a measure to inhibit the process of desertification. Water shortage is one of the main factors limiting agricultural production and settlement in dry lands. Supplemental water is necessary especially in the drought period. In the case where there is no irrigation system, the development of water resources can not only be used as a measure of water conservation for supplemental water utilization and soil moisture regime, but also as a measure of soil eroded reduction by run-off. Off course this will also end up with improvement of eco-system.

Another important measure for anti-desertification or land degradation is soil improvement. Basic information on soil should be used to prepare the plan for proper utilization of farm land. This will include methods of cultural practice, crop varieties, crop sequence and soil management. Improvement of physical and chemical properties of soils results in higher crop yields. Besides the high cost of chemical fertilizer utilization, locally available organic matter should be used as soil amendment. Vegetation by legumes as cover crops or green manure is worthwhile promoting.

Strengthening projects concerning increase land productivity and conservation is necessary. The need of land resource conservation is only realized by a small group of people, especially only those who are working in the field of conservation. The rising demands of an increasing population and deterioration of crop land will bring an end to Thailand's agricultural surplus. Data from research on clay loam soil type with 9 per cent slope showed the erosion of soil approximately 87 ton per ha. per year or soil loss was 6.7 mm. depth. Proper cultivation practice is an urgent need for resource conservation and it cannot wait anymore.

Socio-Economic Aspects

With Population explosion the cultivated area of each family has gradually dwindled and, at the same time, with such a progress of development the people are longing for a better standard of living. However, as the majority are farmers, they have to make every endeavour to adopt double cropping in order to earn more income.

But in the dry season there is no natural supply of water to be headed up by means of diversion irrigation, while in the wet season there is too much water in some years as to cause destructive floods and to affect adversely the crops. Thus it becomes necessary to construct a storage dam to retain the escaping excess water in the wet season as a remedial measure against flood control and also for use in the dry season. To increase yield-producing capacity, the dike and ditch in the diversion irrigation project have been constructed. In the area where the contribution of an adequate supply of water is available, the land consolidation has been formulated compatible with such area.

In addition to the people enjoying the benefits derived from the storage dam in the field of agriculture, this dam will be further used for producing electric power from water for feeding industrial sectors which will be capable of converting raw material into finished products.

In view of increasing products and double cropping, it is essential to have transport routes as outlets for the products to be brought to the market all the year round. These are in the form of feeder roads over the canal banks and embankments to join the main highways or communication canals or rivers.

Transport of goods by boat costs less than that by rail or road. Therefore, it becomes necessary to provide for river training on the main rivers which have been silted up in order to ensure year-round navigation.

Under the land development programmes it was found that the socio-economic status of Thai farmers has been improved, with yield per area increases due to soil improvement and proper management. Data from the Department monitoring and evaluation showed satisfactory farmers' income. Farmers who live in the central acid sulfate soils previously received a paddy yield of only 1.2 ton/ha., after utilization of marl accompanied by recommended fertilizers, they can double that yield.

In addition, improvement of socio-economic status of farmers who live in the area of land development project, for example the project located in the upper South, showed satisfactory increases in their incomes of up to 3 times after 5 years of project initiation. Similarly, another land development project implemented in the North, known as Thai-Australian Land Development Project, has not only raised yield (in case of rice from 700 kg/ha. to 1,400 kg/ha.) but has also enabled a significantly larger area to be cultivated. As a result, the value of household production from the upland plots has increased almost five-fold.

Insurance Against Risk and the Effect of Drought

Besides the provision of water by irrigation, the conservation of water in the natural depression of development of water resource with effective water utilization should be seriously implemented. The Government has set up a national committee to take responsibility for the development of water resource with objectives for domestic consumption, livestock and fish raising, intensive agriculture in dry season and for supplement water in the growing season during the drought period. Projects of small-scale water resource development have been strenghtened.

In order to bring water to crops it is sometimes necessary to develop cultivars which enable drought tolerance. Selection of crop varieties with such characteristic can significantly reduce the crop damage. In areas where drought problems always occur what and when to grow should be very carefully planned.

Last year, Thai farmers had faced the problem of flood damage in the wet season cropping. With provision of seeds from the Government, they could grow double crop in the next dry season. This resulted in recoverage of crop productivity from their farm land. Not only seeds but also credits etc. should be made available in time of need.

Strengthening Science and Technology at the National Level

The preparation of national economic and social development plan must include and stress national resource conservation. Utilization of natural resources which has been under-taken without technical know-how will accelerate desertification process. There is a very small group of people who are aware of the effect of improper use of natural resources. How to make the productivity from natural resources is not hard to do but how to increase or only even maintain such productivity is not so simple. Thus, the problem of environmental deterioration and resources mismanagement needs to be solved. The search for technology for effective natural resources utilization has to be strengthened and accelerated.

The Government science and technology organizations need to be strengthened to promote new scientific and technological inputs which are appreciatively useful and applicable to the national economic, social and environmental conditions. Therefore, international conferences can yield great benefit in the exchange and transfer of technology and science related to desertification aspects. These should be held yearly in selected countries. Selection of host countries might be considered from the degree of desertification.

Integration of Anti-Desertification Programmes into Comprehensive Development Plan

To improve the management of basic resources and rehabilitate environmental conditions is one of the five national development objectives presented in the fourth national economic and social development plan. This includes particular emphasis on the allocation and rehabilitation of land, forest, water and mineral resources for optimum economic efficiency. In order to implement the new integrated development strategies, the plan should include the measures of proper management to limit the deterioration of these resources. This has been done in several implementing projects such as Thai-Australia World Bank Land Development Project, Nong-Plub Land Development Project, Tung Kula Ronghai Rural Development Project, etc. These projects have been implemented by several governmental agencies. The implementation of the above mentioned projects has integrated the anti-desertification programmes into a comprehensive development plan.

For example, Tung Kula Ronghai Rural Development Project located in the North-east covers the area of about 3,370 sq.km. with 275,000 population. Farmers who live in this area are very poor. The reasons are:

1) Very low soil fertility with saline problem and poor water holding capacity.
2) Flooding in rainy season and serious drought in dry season.
3) Poor technology.

The Government has realized the need for a comprehensive plan as area approach was approved in 1979. Beside the other main activities presented as the project components, it does include the activities of:

1) Survey and land-use planning.
2) Providing recommendations and services in soil improvement and reclamation, soil and water conservation.
3) Research in the fields mention in (2).
4) Construction of farm ponds.

The activities presented above are always included in the comprehensive plan of other land development projects. The aim is to improve land productivity for permanent utilization.

USSR

Desertification Control and Desert Development in USSR

by

A.F. Bagayev[*] and I.S. Zonn[**]

The problems of integrated research and economic development of the arid and semi-arid zones of the Soviet Union are becoming increasingly important. This is conditioned, in the first place, by the constantly growing population of the country and by the zones' physical area.

It is for this reason that the development of deserts whereby they are transformed into fertile oases becomes a matter of great concern.

Deserts and semi-deserts in the USSR occupy an area of around 300 million ha., or 14 per cent of its entire territory (A.G. Babayev, Z.G. Freikin, 1977). Nearly all of them are situated in the Kazakh SSR, the Uzbek SSR and the Turkmen SSR. Within the desert belt (between 51° and 80° EL) there are the following well-known desert areas, featuring different physical-geographical peculiarities: Kamenisty Ustjurt; Circum-Caspian sand-clay plain; sandy Trans-Caspian Karakums; Kyzylkums; Mouyounkum; Betpak-Dala; Circum-Aral Karakums; Sary-Ishikotrau; clayey Golodhaya Steppe; the Karakalpak Steppe; Soundukli sands and other smaller areas.

The vast area of the USSR deserts and semi-deserts features a great variety of climatic conditions. The one common characteristic drawing the above areas into the category of deserts and semi-deserts is a very poor available water supply. The deserts of Central Asia normally get around 100 mm mean annual rainfall, which varies between 80 mm and 250 mm in the central regions of Karakums and Kyzylkums (in piedmont areas).

One of the climatic features of Central Asia is seasonal precipitation, with no less than half of the rainfall occurring in spring and the remainder in late autumn and winter; summer rains are rare.

This makes it possible to distinguish two seasons in the deserts as well as in the entire plain part of Central Asia and Southern Kazakhstan: the dry season (from mid-May to mid-October), and the wet season, lasting for the rest of the year. Naturally, there are sometimes departures either way from this regularity, but on the whole the pattern persists.

The mean annual air temperatures increase from 5.0° C to 16.6° C southward. In the annual march of air temperature, the minimum always occurs in January and the maximum in July (Table 1).

Scarce rains, falling in particular seasons, create a very high air dryness, especially in summer and early autumn.

The high temperatures and air dryness, which may last for five months and even longer, cause an intensive evaporation from the soil and water surface. Under desert conditions, evaporation is 20 to 25 times the amount of rainfall, reaching 1,400-2,300 mm. This gives rise to soil drought, i.e. lack of soil moisture, desiccates the top sand layer and increases plant transpiration.

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Table 1. Climate of Deserts in Central Asia

Meteo-stations	Elevation above s.l.	Air temperature °C			Annual rainfall
		January	July	Mean annual	
Ashkhabad	219	1.4	30.7	16.3	230
Zeagli	142	–1.6	31.3	15.2	93
Kizyl-Atrek	22	–5.2	28.5	17.1	188
Repetek	185	1.1	31.2	16.1	113
Tamdy	220	–4.1	30.0	13.4	108
Turtkul	85	–4.9	28.2	12.4	97

The climate of the plain part of Central Asia, i.e. its deserts and oases, is characterized by an extended vegetation period, from 160 to 250 days. During this period, the aggregate of air temperatures over +10° may range from 2,000° to 5,000°. Winters, as a rule, are short of snowfalls and are dry. Yet, one third of all the winters in the Central Asian deserts are not without snow cover. There are winters when the snow cover stays as long as 30 to 40 days, with the depth of snow drifts reaching 70 cm. When the snow covers pasture vegetation, impedes cattle grazing and brings about famine and loss of human life, it presents a real danger. Especially dangerous is the snow carried by winds at 4 to 9 m/s velocity and falling at temperatures –20° to –30°.

The desert areas are characterized by the high level of solar heat (50-75 kcal/sq.cm. of solar radiation).

Wind is a constant phenomenon of the desert. North-easterly winds dominate the Central Asian plains in winter, their mean annual velocity from 2.5 to 5.0 m/s. The highest wind velocities are recorded in spring-time. A strong wind, of 15 m/s and more, can be encountered in the Central Karakums roughly 10 days a year, Kyzylkum, 11 days and in the South-eastern Karakums, up to 50 days a year.

The strong winds always cause dust storms. A wind of 4-5 m/s velocity is capable of stirring the sands. The dust storms mainly occur in summer, at wind velocities of 7-10 m/s and higher, lasting from 2 to 6 hours. In Kyzylkum and the Northern Karakums, dust storms account for 20 to 30 days a year; in the South-Eastern Karakums, 40-50 days (in Repetek Area even 60 days) and in the western part of Central Asia, 50-60 days a year.

As in the case of dryland management elsewhere in the world, economic development of the USSR deserts and semi-deserts is based on the water resources. These include precipitation, local surface run-off, allochthonous rivers and, finally, groundwater.

The drainage network of Central Asia is extremely poor, with many rivers being lost in the sands and forming dry beds and deltas. The largest allochthonous rivers of the USSR deserts, Amu-Darya and Syr-Darya, cross the sand deserts and reach the Aral Sea. Their annual run-off measures around 60 cu.km. and 31 cu. km. respectively. These rivers, together with the rivers Zeravshan, Murgab and Tedjen, are responsible for the formation of the sands in the Karakums and Kyzylkum. At present, their flow is largely used for irrigation purposes. In the south-west, the River Atrek flows into the Caspian Sea, while the Ili and Karakol flow into Lake Balkhash.

These rivers play a significant role in recharging groundwater reserves by way of an infrabed flow. Their waters, fresh near the delta and growing increasingly mineralized the farther away from it, supply the wells, determine the nature of desert plants, their changeability, depending on the sources of nutrition.

In addition, groundwaters are recharged by temporary run-off from Kopetdag, the Nurat, Zarabulak and other mountains. Among other sources of their recharge are seepage waters from the main canals, irrigated fields, and the water of temporary run-off filtering into the solum.

There are no conditions in the deserts for the formation of a considerable surface run-off. This is due to the high infiltration capacity of the soils, inadequate precipitation and high air temperatures. However, man-made impervious sites or natural, takyr catchments may yield in different regions an average 5,000 to 35,000 cu. m. of rainwater from 1 sq.km., (Leschinski, 1974).

In the Karakums alone, where takyrs or takyr-type areas account for 3.1 million sq.km, the total catchment of fresh water equals 35 cu. km., which is almost equivalent to the Syr-Darya run-off. According to G.T. Leschinski, (1974), the use of these water resources for economic purposes in optimum quantities, close to the values of the mean annual run-off, calls for conscientious management of the run-off regimen by accumulating it in the buried drains. This makes it possible to build up, when necessary, fresh groundwater reserves to meet the requirements of livestock grazing on distant pastures.

Most of the groundwater in the deserts has a high mineral content. In some areas mineralization reaches high values, of 50 to 100 g and more of the solid residual per 1 litre of water. Geographically, the desert groundwater salinity is not uniform: in the western part of Turkmenistan from 0.1 to 3.0 g/1 and up to 15-50 g/l; in Kyzylkum, 3-15 g/l and in the Karakums, from 1.5-3.0 g.l. to 30 g/l.

In summer, groundwaters, mineralized up to 6.0 g/l are of great economic value, as they are drunk by sheep. In winter, when the sheep can consume even more saline water, it is still valuable with a mineral content of 13 g/l. As the degree of mineralization reaches 16 g/l, the water can only be consumed by camels in winter; any further increase of salinity makes water absolutely unusable.

Saline marine, ground- and drainage waters constitute the largest, practically inexhaustible source of water. For this reason, efforts of the last few years have been concentrated on the improvement and elaboration of reliable techniques of water desalinization. Significant progress has been made in this area: big installations produce tens of thousands cubic metres of fresh water per day at a cost making it suitable for the use in industrial and communal water supply. This, however, is only possible if the cheap sources of heat energy are used, e.g. the sun, wind, natural gas, in large desalinization units, which are, in fact, water desalinization plants.

In this respect the conditions of the deserts in Central Asia and Kazakhstan are quite favourable, as the resources of the Caspian Sea and saline groundwaters here are unlimited. Some industrial enterprises for example in Krasnovodsk, Schevchenko are supplied with the Caspian water desalinized in the large industrial desalinization plants.

The aridity of climate manifests itself in the weakly pronounced biological and soil-formation processes, with the typically low for desert soils content of humus, poor structure and high salinity. The soil cover essentially consists of desert grey-brown, desert-sand, sand loam and loam soils, of takyrs and solonchaks. Under conditions of excess soil moisture, the river valleys and deltas feature hydromorphic soils: alluvial-grassland, bog-grassland, grassland-takyr, etc. The piedmont plains enjoying more rainfall, feature serozem soils, formed on loess deposits (E.V. Lobova, 1960).

The difference in soil texture and in agrohydrological properties of these soils manifests itself in the peculiarities of their hydrological regime. This, coupled with climatic conditions, is reflected in the composition of the vegetation cover, the rhythm of its development and productivity, the vegetation being represented basically by psammophytes, xerophilous underbrush and halophytes.

Latitudinal differences in the hydrothermic regimen of the desert zone are reflected in the overall appearance of the soils and vegetation cover. The northern section of the zone is characterized by prevalence of desert grey-brown soils, alkalinity and alkali properties very much in evidence. The moderate hydrothermic regimen does not favour the accumulation of carbonates in the soils here. Although insignificant, the rainfall is evenly distributed over the summer period, facilitating the development of perennial underbrush with a late vegetation, such as sage-brush and thistles. It is for this reason, that the northern section of the desert area is a zone of sage-brush deserts, its vegetation rather sparse.

Much more diverse is the vegetation cover of the sand deserts, Sam, Mouyounkum, Bolshiye and Malye Barsuki. Here, vegetation is represented by a combination of species typical of mesophytic and xerophytic flora.

The soils of the southern section of the deserts are highly carbonaceous, grey-brown and serozem. The high carbonic content of the soils is due to a very dry and hot summer. Such hydrothermic regimen helps to accumulate carbonates in the soil horizons and in the underlying materials.

The spring maximum rainfall allows a far more lush vegetation unlike the northern section, where there is no such rainy season. The warm humid springs stimulate the development of a specific type of vegetation – ephemerals and ephemeroids. With the advent of a hot and dry summer, ephemeral vegetation dries up. Hence, the ecological conditions favouring the vegetation of plants in the northern section during a warm period and in the southern section during a cold period of the year. In the former case, vegetation in winter is impossible due to low temperatures and thin snow cover, while in the southern section, climatic conditions encourage the development of ephemerals and ephemeroids. During the summer, vegetation in the south is impossible for xerophytes due to lack of rainfall and to extremely high temperatures; in the northern section in summer only the late-vegetating desert xerophytes can vegetate.

Within the desert zone, three major categories of pastures can be distinguished: those of sand deserts, gypsum pastures and clay pastures.

Sand desert pastures occur in large tracts in the southern section of the desert zone, their total area being in excess of 44.8 million ha. The pasture vegetation cover is dominated by shrubs, grasses and annual ephemerals. The composition of pasture vegetation allows year-round pasturage of sheep and camels. Mean annual reserves of eatable fodder here are 1.01 cwt/ha, while the annual pasture rate per single sheep is 9.4 ha.

Gypsum desert pastures are widely spread, occupying Plateau Ustjurt, a number of tracts in Trans-Unguz and residual surfaces of tertiary-cretaceous plateau in the South-Eastern Kyzylkums. Their total area is 38.0 million ha. The soils are essentially grey-brown, slightly carbonaceous, the carbonic content increasing southward. Dominant in the vegetation cover of the typical desert pastures are sage-brush-thistle aggregations. Their advantage consists in that these plants live all year round, although their yielding capacity is low (from 0.6 to 2.8 cwt/ha). Fodder reserves vary from year to year; here these fluctuations are more pronounced than in the sand desert.

Clay desert pastures account for over 18.6 million ha. and are popular in the south-western part of the Turkmen SSR, in the Amu-Darya and Syr-Darya ancient deltas, in the Tadjen-Murgab Interfluve and in other areas. These pastures feature sage-brush, perennial and annual thistles, sometimes, ephemeral grasses. The composition of fodder crops makes these pastures more suitable for camel pasturing, autumn and winter being reserved mainly for sheep grazing. The eatable fodder reserve varies on the average from 0.8 to 2.2 cwt/ha. during a year.

The peoples of Central Asia and South Kazakhstan have had, from time immemorial, to resort to the desert resources in their economic activities. For centuries, however, the deserts had been developed in most primitive ways and at slow rates. More often than not, man had found himself impotent when confronted with the rugged environment of the desert and had had to give way.

In the USSR, arid lands are formerly outlying areas, which used to be regarded as a raw material base for the development of industry and agriculture of tzarist Russia.

During the years of Soviet power, especially in the course of the country's industrialization, desert development has become a task of national importance, an intergal part of the economic policy. The preparation and realization of the plans for desert area development were based on the concepts, reflecting the substance of the Soviet social structure; the development should be in the interests of the national economy with a view to raising the standard of living of the people; it should proceed from the necessity of bringing the economy of formerly backward areas up to the level of economically developed ones on the basis of the latest achievements of science and technology, of the Leninist national policy.

This has called for an integrated desert development to involve in the process the natural, economic and labour resources of the areas.

The specific features of the desert zone have made it expedient to use most of the areas for livestock grazing, to convert areas with adequate water supply for irrigated farming and to develop extractive industry in the deserts, manufacturing in the oases. This, in turn, has made it necessary to develop the deserts through non-labour-intensive sectors of economy, involving few people, well-equipped technically.

A steady general progress of science and technology enables us to increase from year to year the rates of developing arid and semi-arid territories. This development proceeds in the following major areas: 1. irrigated farming and water management development; 2. grassland livestock farming; 3. forest reclamation; 4. extractive industry. A review of accomplishments in these areas follows here-under.

Irrigated Farming and Water Management Development

This takes the leading role in desert development. The desert is generously endowed with all natural resources essential for farming, except one – moisture. This is compensated for by irrigation. In Central Asia irrigation has taken centuries to develop. The total area of ancient irrigation equals 8-10 million ha. (Andrianov, 1974). Its old age and steady development are due to the great advantages provided for by climatic conditions of the area. These manifest themselves in the possibility of cultivating such crops as cotton, rice, grapes on irrigated lands and of having two, and sometimes even three, harvests of fodder crops and vegetables.

For centuries, the people living in the deserts of the Soviet Union have developed and used all kinds of techniques of utilizing the available water resources for farming. Some of these were unique, for example, the arrangement of underground galleries (karez) for intercepting the subsurface run-off from the mountains, or artificial formation of sub-surface fresh water lenses (floating upon the saline groundwater) by letting out the rainfall from takyr catchments through special wells.

However, the primitive technology and the social and economic conditions of the pre-Soviet period ruled out the possibility of full use of the local and allogenic river and ground waters.

During the years of Soviet power, the system of arid land irrigation in the USSR has been entirely changed. This, in the first place, is reflected in the radical remodelling of the old irrigation network, which sharply raised the productivity of irrigated areas; in the integrated use of the run-off of the largest rivers of Central Asia and Kazakhstan: Syr-Darya, Amu-Darya, Ili, Murgab, Tedjen, Zeravshan, Vakhsh; in the comprehensive development of the reclaimed lands. Dozens of major water management projects have been built in the basins of the above-named rivers: on the Amu-Darya – Takhiatash and Tuemoujun headworks, on the Syr-Darya–Fark – had, Kairakkum, Char-Dara and Kzyl-Orda water reservoirs, Kazali headworks.

Also built are Amu-Bukhara pumped water canal, Karshi Canal, Big Andizhan and Big Namangan Canals, Karakum Canal named after V.I. Lenin and other works.

The area of irrigated lands in the USSR desert zone has more than quadrupled, i.e. it increased from 3 to 15 million ha. during the years of Soviet power. This has made it possible to raise considerably the production of unginned cotton. The following table shows the growth of irrigated areas in two Central Asian Republics:

Table 2. Growth of Irrigated Areas (million ha.) and Cotton Production (million ton)

Indicator	1940	1965	1970	1975	1979
Uzbek SSR					
Irrigated area	2.28*	2.64	2.70	3.01	3.39
out of this, planted in cotton	0.92	1.56	1.71	1.77	1.83
Production of unginned cotton	1.39	3.75	4.50	5.01	5.76
Turkmen SSR					
Irrigated area	0.45*	0.51	0.64	0.82	0.90
out of this, planted in cotton	0.15	0.26	0.50	0.49	0.51
Production of ungineed cotton	0.21	0.55	0.87	1.08	1.22

* Data of 1950

On the basis of technologically advanced irrigation systems there evolved a definite regional specialization of irrigated areas with specific combinations of irrigated crops. Regional specialization of agriculture in the USSR has made it possible to transform Central Asia into the main cotton-growing area of the country. Where there is adequate water supply, cotton-growing is being developed in combination with vegetables, melon crops, fruit and grapes, grains and grain-fodder crops, perennial grasses (alfalfa). Irrigated farming is integrated with dairy cattle production, sericulture, apiculture and grassland livestock farming outside the oases.

The application of new technology in the irrigation of desert lands, namely, the use of anti-seepage linings and of pipelines on the irrigation network, of buried horizontal and vertial drainage, of regulating structures and wide introduction of advanced irrigation methods (sprinkling, sub-soil irrigation and drip irrigation) now make it possible to save a substantial amount of water in the irrigated oases, which used to be wasted as seepage losses and non-productive evaporation.

A characteristic feature of the present stage of reclamation development in our country as a whole is, as was noted above, its integrity. It was in the Golodnaya Steppe, Uzbek SSR, that the development of virgin desert and semi-desert lands assumed the greatest scale. At present, here, in what used to be a dry desert, there are about 500,000 ha of irrigated lands, out of which over 250,000 ha are located in the new zone. More than 30 cotton-growing state farms have come into being with modern engineering service lines: 180 km railway, about 1,600 km motor-roads, 235 km power transmission lines, 250 km water pipelines, nearly 290 km gas pipelines. There is a complex of construction works and building material plants, which allowed the construction activity to be put on an industrial basis. This went on alongside with the development of agriculture and social infrastructure. A detailed description of the world-famous project in the Golodnaya Steppe was presented as the basic document at the United Nations Conference on Desertification (A/Conf. 74/23). As of now, the development of the Golodnaya Steppe has been completed, and the experience gained is being used with success in the development of other major projects of the semi-desert zone – the Karshi Steppe and the Djizak Steppe.

The Karshi Steppe covers an area of about 1 million ha. Its main water course, the River Kashkadarya, its streamflow fully regulated, is capable of supplying water for 150,000 ha of land intended for thin-fibre cotton growing.

However, the planned measures to improve the available water supply for the lands of the Karshi Steppe have failed to solve the problem fully, because the Amu-Darya water resources will have to be involved.

At present, a wide range of activities is underway to irrigate and develop the lands of the Karshi Steppe. The Project first stage includes the construction of a river intake and envisages the development of 200,000 ha.

The Amu-Darya water is supplied to the Karshi Steppe via the 200-km long Karshi Main Canal, having a discharge of about 200 cu.m./s (first stage). The water is lifted to the height of 132 m by means of six pumping stations. The flight of the Karshi pumping stations is unique. The installed capacity of their 36 electric motors is 450 mW, the capacity of each pump being 40 cu.m./s.

At the 80th kilometre of the Karshi Main Canal, a Talimardzhan Reservoir with storage capacity of about 1 billion cu.m. is under construction to ensure a year-round supply of water from the Amu-Darya and to allow a subsequent use of the water stored in winter for irrigation in summer. This permits the halving of the carrying capacity of the feeding canal and the power of the pumping stations.

The working part of the Karshi Main Canal with a rate of 350 cu.m./s begins immediately beyond the Talimardzhan Reservoir. The anti-seepage lining increases the Canal efficiency to 0.97. Eight per cent of the total length of the systems of inter-farm canals exceeding 2,000 km are lined with concrete, 66 per cent are built of parabolic precast reinforced concrete flumes, and 26 per cent are built of asbestos-cement pipes. The total length of the closed drainage system built of earthenware pipes is 8,000 km. A part of the territory will be provided with vertical drainage. The length of the carrier-drain network is nearly 2,000 km.

The largest project of water resources management in the deserts of the Soviet Union is the Lenin Karakum Canal. It diverts water from the Amu-Darya and takes it along the 1,400 km-long channel as far as the River Atrek. The discharge across the headwork will be 800 cu.m./s, and the flow diverted from the Amu-Darya – 18 cu.km. The Canal anticipatec command area is 1 million ha.

1,100 km of the Canal has been completed already. A number of reservoirs have been built or are still under construction to regulate the free autumn winter run-off of the Canal. Their aggregate storage capacity ultimately will equal 1.8 cu.km. Already completed are Hauz-Khan Reservoir (875 million cu.m.), Ashkhabad Reservoir (48 million cu.m.), Kopet-Dag Reservoir (190 million cu.m.). Besides, at the headworks of the Karakum Canal, a large Head Zeid Reservoir of 3.5 cu.km. storage capacity is planned to regulate the Amu-Darya run-off.

The Canal resolves a complex of tasks: irrigation of lands, better water supply for pastures, water supply for town and rural areas, industrial water supply, fish-farming, navigation. The Canal can also be used for power generation with the aid of hydro-electric power stations or pump-storage plants.

The construction of the Karakum Canal is extremely efficient: when 1 million ha. in the Canal command zone are fully developed, the total net profit from agricultural production to be enjoyed by both the individual farms and the state will amount to 1.25 billion Roubles per year.

Great importance is now attached to the irrigation of sand tracts adjoining the oases, which could be used with simple levelling, given the right irrigation techniques. The area of such tracts in the desert zone of the USSR is about 2 million ha. As long as they are located near the developed lands, not far from the operating irrigation systems, their development is much cheaper than water transfer over long distances. According to the data of the Desert Institute of the Turkmen SSR Academy of Science, the rate of irrigation of 5,000 cu.m./ha. and an application organic and mineral fertilizer at standard rates allow to obtain a high yield of sorghum green mass (600-900 cwt/ha), of corn (500 cwt/ha), alfalfa (500 cwt/ha); melons yield 200-250 cwt/ha, water melons – 300-500 cwt/ha. and pumpkins 200 cwt/ha.

Whatever the methods of improving the water supply in the desert, the basic resource is groundwater. It is only in isolated places, where takyrs are prevalent (Kyzylkums, Western Turkmenia, Central Karakums) that they make use of precipitation accumulated in wells and rain pits. Out of the numerous techniques of preserving precipitation in the desert, the best results are achieved by accumulating the run-off in the natural underground drains, whereby the fresh atmospheric water forms a kind of lens, floating upon a sub-surface saline one. This phenomenon is sufficiently well studied in the Karakums, under conditions similar to real, where the zones of aeration and permeable rocks are represented by sand deposits.

Such subterranean reservoirs (of the sub-sand lens type) ensure a year-round water supply for cattle in the most distant grazing lands on the economically acceptable basis. However, takyr catchments are not to be found everywhere in the desert, which is why they arrange small asphalt-cement catchment sites. At the moment, researchers are looking into the possibility of producing new, more economical, light-weight, heat-resistant, anti-seepage materials, capable of forming a tear- and waterproof surface. While a single hectare of a natural takyr catchment yields an average of around 300 cu.m. of fresh water per year, a minimum of 700-800 cu.m. can be obtained from the same area of an artificial catchment. This amount, mixed with mineralized water, is sufficient for a herd of 800 sheep throughout a year. Given the necessary materials, catchment sites can be built anywhere in the desert for collecting the adequate amount of atmospheric moisture and placing it in the aeration zone, thus arranging unusual subterranean water reservoirs (Babayev, 1976).

Groundwaters play a leading role in watering the pastures and making water available to human settlements. Even when the grass-stand is good, a pasture without wells, or with saline water wells, is used primarily in spring, as juicy animal feeds make it possible to reduce water requirements. With a 6 g/l mineralization rate, the water can be consumed all year round; at 6 to 13 g/l – in autumn and in spring; at 13-16 g/l only in winter. More saline water is not suitable for sheep, but is good enough for camels in winter. A sheep will need 1.5-2.0 cu.m. of water per year; a camel needs 11 cu.m. of water. Although the sheep water requirements are low, they are practically primary consumers of water because the sheep pastured in the desert run into millions.

Under new social and economic conditions, the advanced technology introduces new methods of water supply for pasture watering. Increasingly used are boreholes, both flowing and pump-actuated; construction of water wells using metal gauze and concrete rings is underway. New means of water delivery are introduced; water distribution by pipelines and delivery in tank trucks to waterless pastures.

Most wells in the deserts of Kazakhstan and Central Asia are not deep: 98 per cent up to 30 m; 1.5 per cent from 31 to 99 m, the rest up to 100 m and deeper (V. Kunin, 1959). The deepest wells are to be found in the South-Eastern Karakums, some of them reaching 250-270 m.

The well yield and pasture productivity determine the distance over which the sheep are driven, the optimum driving radius being 5 to 7 km.

Pipeline water delivery to pastures is widely practiced in Kazakhstan, with about 100 million ha. of desert and semi-desert grazing lands successfully watered, out of the total of 180 million ha. The largest in the world, Ishim and Boulayev water pipelines, are built here, each having a daily delivery rate of 50,000 cu.m., their total length being 1,700 km. 30 group water supply systems are being planned to meet the requirements of agriculture. These will have a total length of about 20,000 km and an aggregate capacity of 360 million cu.m. per year.

Desalinated groundwaters have been added to the available water sources for the past few dozen years. At Krasnovodsk (Turkmen SSR) and Schevchenko (Kazakh SSR) evaporation and adiabatic desalination units were built of 13,200 and 15,000 cu.m. daily capacity respectively. In 1973, at Schevchenko the world's first atomic desalination unit of 120,000 cu.m./day capacity was commissioned. Small desalination units, using sun and wind energy are being designed.

However, in the USSR, just like in many other arid zones of the world, irrigable areas as well as water requirements of the growing towns, industrial centres and livestock by far exceed local water reserves. At the same time, the vast territory of the USSR North suffers from excess moisture, with many of the world's largest rivers (Ob, Yenissei, Irtysh, etc.) taking their waters to the North. For this reason, in resolving radically the problem of water supply for the USSR desert areas, of particular significance is the envisaged inter-basin flow transfer, involving part of the northern and Siberian rivers to be diverted to Central Asia, Kazakhstan and the Volga Basin. Grassland livestock management farming.

The Central Asian Republics and Kazakhstan account roughly for one-third of the natural grasslands in the Soviet Union, i.e. about 122 million ha., lying in the desert zone.

The total number of cattle in the country's deserts and semi-deserts is 50 million, out of this 17 million are sheep, which includes 13.5 million Astrakhan breed (Nikolayev et al., 1977).

This breed (also called 'karakul'), produced in Central Asia, has become world-famous owing to the nonpareil beauty of the sheep's fur; it is now one of the most numerous sheep breeds reared in the Soviet Union. The use of the cheap grassland fodder affords this branch of animal husbandry wide opportunities for further development and high profitability. Considering the fact that apart from astrakhan skins, grassland sheep farming in the desert yields tens of thousands of tons of meat and wool, it will be easy to understand the great importance of this branch for the national economy of the Central Asian Republics and Kazakhstan.

In the pre-revolutionary period, they used to rear in the desert pastures of Russia sheep for karakul fur and lard, local coarse-wool breed of goats and single-humped camels. Small privately-owned livestock farms were nomadic, with seasonal wanderings, whereby the livestock was managed under a grazing system throughout the year. This often resulted in mass murrain when winters were severe or the crops failed and there was no animal feeds available. During the years of Soviet power, the principles and the manner of desert pasture utilization have changed dramatically. The setting up of collective and state farms, which incorporated the small individual nomadic farms, made it possible to give up nomadic livestock management and to introduce a driving-pasture system. This system is based on the fact that the main stock is the property of collective and state farms, only limited numbers of stock being in private ownership. The grasslands are distributed between the farms in proportion with the numbers of stock they possess. The stock is driven on a seasonal basis over an area belonging to a particular state or collective farm. A communal ownership of livestock has facilitated provision of veterinary services and eliminated mass epizootic cases.

Planned livestock farming has determined regional specialization of the industry development to meet the requirements of national economy, taking into account the natural potentials of particular territories. Thus, the desert has become an area of astrakhan sheep farming (gray, black and other colour shades). The state-owned scientific bodies conduct the breeding and pedigree cross-breeding experiments, while the administrative and construction units build water-wells, which later become the property of state and collective farms. In the case of driving-pasture system, only herdsmen with wives and children of pre-school age are constantly with the herds, whereas the main body of the farmers live in a settlement, belonging to the state or collective farm, or on the livestock farm itself.

The establishment of large sheep- and camel-breeding farms allowed the introduction of the planning of a scientifically-substantiated and consistent use of grasslands of the same area. The livestock farms follow a system of grassland rational utilization to exclude the harmful effect of over-pasturing on the pasture vegetation and soils. The system is based on intra-farm land management with long-range plans of pasture utilization. Such a plan envisages the introduction of pasture rotation in the preparation of a seasonal feed balance, specifying protein deficiency and sources of its replenishment, seasonal distribution of livestock over the pasture ranges, advanced grazing techniques, grassland improvement.

Wide-scale comprehensive construction is going on in the desert pastures, with full and equibalanced water supply over the entire pasture areas, and with remodelling of the existing water delivery network; fodder resources are being improved by changing the composition of desert pasture vegetation, by increasing the biological productivity and setting up forage production farms on irrigated lands; sheep-breeding farms are consolidated with a view to further production specialization and concentration. It is to be emphasized that radical improvement of desert pastures without irrigation constitutes one of the most remarkable achievements of Soviet science and practical experience.

The basic methods of vegetation cover optimization are fundamental and simplificated grassland improvement. Fundamental grassland improvement involves soil treatment, although under desert conditions it does not always fully destroy the natural vegetation. Even a rough ploughing ensures adequate moisture accumulation, eliminating the effect of grassy turf on the seedlings of shrubs and semi-shrubs. The grass cover in the man-made shrub pastures is formed later from the ploughing 'lapses' and the stock of seeds always present in the soil.

Simplificated grassland improvement consists in the undersowing of plants to the existing grass stand without soil treatment. This method is meant to apply to water-well sands and loose-sand grasslands with highly thinned vegetation. The seeds are placed in the soil by driving a herd of sheep over them. A special pre-treatment of seeds prior to sowing is also used. The seeds are immersed in a thick solution of sand and clay, whereupon they are removed and dried out. Heavy prickle 'granules' are formed which, once sown, do not get blown out and cannot be drifted by sand to a considerable depth, while the clay particles stuck to the seeds ensure a good nutrition of the seedlings in the first days of their life.

On the basis of experimental data, obtained in different locatlities of the desert zone of the Turkmen and Uzbek SSR, and with due regard to the practical experience of grassland improvement the following seed sowing rates have been established: Haloxylon aphyllum (Minkw.) Jijin, 5-8.9 kg./ha.; sage brush, 0.5 kg./ha.; Russian thistly, 10 kg./ha.; Salsola Richteri Kar, 10 kg./ha. and annual sow thistly, 5-10 kg./ha. (Nechayeva et al., 1978).

In the first year, production of the above-ground mass is insignificant, there being no grasses at all. These are suppressed by ploughing. However, in the 3rd-4th year, a grass layer develops from the stock of seeds available in the soil.

The phytomass (above- and under-ground) consists of shrubs, semi-shrubs and grasses, reaching 200 cwt/ha., which is 6 to 30 times the natural amount of phytomass.

Man-made grasslands can be used for livestock feeding as soon as they are 2-3 years old. They have a long life and need no extra tending: in the case of early-maturing species with a short life-cycle, the pastures can last from 8 to 15 years; if the species have a long life-cycle, the pastures last up to 14-30 years.

The establishment of long-term grasslands allows the change of seasonal limitations of natural grasslands by introducing autumn, winter and year-round pasturage, and by raising the yielding capacity 3 to 8 times (Nechayeva et al., 1978).

Large specialized astrakhan sheep-breeding farms set up fenced, well-organized pastures with a good water supply. Such pastures can accommodate 4,000 to 5,000 sheep, serviced by a team of 6-7 people. Several teams are then incorporated to form a mechanized astrakhan sheep-breeding complex. The complex is capable of managing up to 15,000 to 20,000 sheep.

This system of sheep farming is introduced in the state breeding enterprise 'Karnab', Samarkand Region, which has a grassland area of 32,000 ha. As a result, the number of sheep accommodated has increased 1.5 times, the labour productivity of the teams doubled, and the gross output per worker more than doubled.

The new manner of grassland utilization forestalls the danger of desertification, the degradation of the vegetation and soil covers. The establishment of cultivated fenced pastures and introduction of the advanced process of sheep-farming in the desert areas of Central Asia and Southern Kazakhstan constitute the future success of astrakhan sheep-rearing.

Forest Reclamation

Travelling sands in Central Asia account for 5-7 per cent of the entire desert area (Petrov, 1950). These have an appearance of individual spots against the general desert background.

Travelling sands in sand deserts are usually considered to be a manifestation of aeolian processes, conditioned by high velocities of winds, negligible amount of rainfall, scarce vegetation and mellow quarternary deposits widely spread. Among the factors responsible for the growth of travelling sand areas are unwise farming practices in the deserts.

In the deserts of Turkmenistan, travelling sands occupy an area of 1.3 million ha.

Travelling sands consitute dynamic forms of relief. Their movement is determined by the force and direction of prevalent winds, granulometric composition and degree of moisture. In the Karakums, the factors affecting the displacement of sand are constant, only wind is subject to change; it is the wind that determines the intensity of sand movement.

The movement of travelling sands caused by wind results in the formation of sand drifts on irrigated fields, on rail- and motor-roads or pipelines. In the middle Anu-Darya Oasis barchan sands used to drift tens of hectares of irrigated lands in the 1920's-1930's. A complete sand drifting threatened once the town of Turtkul on the Amu-Darya. A catastrophy used to be imminent in the Bukhara Oasis, with sand drifting thousands of hectares of irrigated lands (Petrov, 1950), the travelling sands caused great damage to farmers in the lower reaches of the Amu-Darya, etc.

At present, the following traditional types and designs of mechanical protection can be recommended for use:

1. Upright, tight mechanical fence, 0.3-0.7 m. high, with the unit requirement of straight-stem plant material 90-100 cu.m./ha, or 150 cu.m./ha. for cellular plants.

2. Semi-concealed upright mechanical protection, up to 20 cm high, with the unit requirement of straight-stem plant material 60-90 cu.m./ha.

3. Carpet-type row mechanical protection, with the unit requirement of straight-stem plant material 60-90 cu.m/ha.

4. Carpet-type "longitudinal" mechanical protection, 25-35 cm row width, with the unit requirement of any locally available plant material 30-40 cu.m./ha.

The procedure of arranging an upright mechanical protection is as follows: a 20 cm-deep ditch is dug along a pre-drawn line. Protective material is then placed on one side of the ditch, lifted to assume an upright position, drifted with sand on either side and compacted.

Carpet-type row protections are arranged by spreading the plant material of 5-7 cm thickness. The stability is ensured by placing sand on the row central part.

Carpet-type "longitudinal" protection is normally arranged with straight-stem material, the thickness of protection and its width being 10-15 cm and 25 cm respectively. As the material is being spread along the protection line, the bunches of stems are to overlap one another and to be covered with sand at the joints.

Carpet-type protective fences can be installed any time of the year, but springtime is preferable. In the case of an earlier installation, they fail to retain the planted seeds due to sand drifting.

The inter-row protective fence spacings accepted as optimum are shown in Table 3.

All types of mechanical protection should be installed in the lower part of the barchan chain upwind slopes, where conditions are more favourable for forest-growing and less damage can be inflicted by winds. The following sowing rates/planting rates per 1 ha. of retained area were used in practice: seeds – 3 kg. of Haloxylon, 4 kg. of Salsola Paletski, 3,000 grafts and 3,000 seedlings.

The seeds were planted immediately after the installation of protective fences. The sowing

Table 3. **Distance Between the Rows of Mechanical Protective Fences (in m), Height 30 cm (Stepanov, 1968)**

Wind velocity (in m/s)	Inter-row spacing depending on slope steepness		
	5°	10°	15°
	Upright protection		
Up to 17-18	4.2	3.0	2.1
Beyond 18	3.3	2.1	1.2
	Carpet-type protection		
Up to 17-18	4	3	2
Beyond 18	3	2	1

was carried out by simple broadcasting without placement in seed holes, with placement in seed holes or in rows.

These devised techniques of travelling sand stabilization have made it possible to protect agricultural projects from sand drifts. The techniques were used selectively, depending on the available conditions for forest growing, the intensity of winds and the nature of protected object.

While tackling general land reclamation problems (restoration of shrub vegetation on barchan sands) in areas favouring the growth of forests, characterized by weak and moderate winds (mean annual wind velocities 2-4 m/s), the sands were stabilized using carpet-type row protective systems and the crop stands were established by seed sowing. Where the forest-growing conditions were unfavourable (saline sands, deep sub-terranean waters and strong winds – mean annual wind velocities over 5 m/s) sand stabilization was arranged with the aid of upright cage-type semi-concealed mechanical protection, the crop stands established by planting seedlings.

In some cases, protection of objects proved possible only when specific requirements were met. Canals, drainage header lines, railways, agricultural lands, industrial enterprises could be protected if there was no danger of sand assault in the form of barchans or through a wind-sand flow. The requirements were met by means of installing upright or semi-concealed mechanical protective fences. In the case of Central Asia, where mean annual volume of sand transported amounts to 22-25 cu.m./l.m., the entire incoming volume of sand is arrested by upright semi-concealed mechanical protection systems, arranged in 3 m spaced rows to occupy a 150-180 m wide strip (Stepanov, 1968).

As for the gas, oil and water pipelines, the accumulation of transported sand is viewed as a positive factor, ensuring their protection. The desirable effect is achieved through an arrangement of all kinds of mechanical protection as well as by planting the seedlings of sand-binding plants.

Protection of motorways and prevention of erosion of the slopes and right-of-ways were secured by various means.

Deflation processes on the right-of-ways and on the slopes were excluded by gravel pitching, mud injection or by an application of chemical agents. The technique of blocking the sands, approaching the carriage-way, using mechanical protection is widely employed.

There were cases when conditions were set up to allow a non-accumulation transport of sand across the carriage-way by making the right-of-way slope, pitching it with gravel or by binding agent application.

Thanks to the traditional protective techniques, during 1945-1965 alone nearly 640,000 ha. were stabilized and afforested in the Turkmen and Uzbek Soviet Socialist Republics. In the last years (1968-1978) this area increased by 180,000 ha. (Petrov, 1977). The danger of sand drifts on irrigated lands in the flood plain of the Amu-Darya, the Bukhara Oasis, and the Zeravshan lower reaches was entirely eliminated. Windbreak plantations of 80, 150 and 60 ha. respectively, were provided specially to protect those areas. The total area of protection systems, arranged in the Circum Middle Amu-Darya Oasis sands equals 15,000 ha. The largest hydraulic structure, Karakum Main Canal, took 2,000 ha. of mechanical protection system area. A smooth operation of the Central Asian (Trans-Caspian) Railway was ensured by protective measures, which involved the installation of mechanical protection systems in the total area of around 25,000-30,000 ha. Even now, protective systems of 150 ha in area are installed every year along the railways in Turkmenistan.

Sand stabilization measures, carried out in the deserts of Central Asia with the aid of traditional techniques, eliminated the threat of sand drifting to which towns, irrigated lands, canals and other installations used to be exposed. However, the major tracts of travelling sands, situated away from oases remain intact. Their melioration, on the basis of the present-day technology and farming practices, is not economical.

The problem of reclaiming extensive barchan tracts received particular prominence when industrial and agricultural development of the desert resources was most active. Research undertaken in the USSR for the purpose of solving these problems can be considered as a second stage of evolving the techniques of fighting the travelling sands on a qualitatively new basis, i.e. on the maximum mechanization of labour-intensive processes.

Under the extra-arid conditions of Central Asia, mechanization of sand-binding and forest cultivation has become possible with the introduction of chemical agents to stabilize the sand surface.

Most promising of these in the USSR are considered to be Nerozin(R), petro-product wastes, sulphite-alcohol slop, cotton tar, etc. A full mechanization of labour-intensive processes has been given due consideration, including the possibility of combining sand stabilization and forest cultivation work.

New process of forest planting in barchan sands is carried out with special forest/tree-planting units LPA-1, LMB-1 and others, driven by DT-75 tractor.

The new planting process presupposes the arrangement of 6 m spaced strips running parallel to the chain ridge. In different types of relief (small-, medium-, large- and high-barchan chains) the planting strips can be arranged differently. In the case of small-barchan sands, the seedlings are planted out in between the chains and in the bottom section of the chains proper. In medium-barchan sands, the seedlings are planted out in the interbarchan depressions on the upwind slope to occupy two-thirds of its height. In large- and high-barchan sands, the seedlings are planted out only on the upwind slopes up to two-thirds of their height. Using the recommended scheme, as many as 5-7 strips can be accommodated on the upwind slopes of large- and high-barchan chains.

For mechanized forest planting they use seedlings with a well-developed nervous core system, minimum 30 cm long, the total height above the ground level being 50 cm minimum. Once planted, the seedlings need no tending. To make sure the seedlings will take root, it is advisable to cut two-thirds of the seedling top part prior to planting.

Sand stabilization works are carried out with the aid of various sand-stabilizing machines. Those utilized in the USSR ensure application of a binding agent to the sand surface in strips 1-2 m or up to 10 m wide.

In strip stabilization of upwind slopes, at first the lower-most planting row is stabilized and then those arranged higher across the slope, or vice versa.

Strip stabilization is possible at wind velocities of up to 8 m/s, whereas solid stabilization is possible at wind velocities not exceeding 6 m/s.

The rate of binding agents used per 1 sq.m. of the surface varies depending on the type of agent and the technique of sand stabilization (Table 4).

Table 4. Unit Requirements of Binding Agents Used in Sand Surface Stabilization

Description of binding agent	Type of surface stabilization	Requirement per 1 sq. m.	Thickness of coatings formed (mm)
Nerozin	Solid	0.4 – 0.5	4 – 5
	Strip	0.6 – 0.7	6 – 7
Fuel oil	Solid	0.8 – 1.0	8 – 10
	Strip	1.0 – 1.5	10 – 15
Cotton tar			
Sulphite-alcohol slop	Solid	0.45 – 0.5	10 – 12
Oil	Strip	2	20

Nerozin, oil, fuel oil and other derivatives of petro-products enable us to obtain protective coatings of certain elasticity, whereas cotton tar and sulphite-alcohol slop produce non-flexible crusts. Elastic coatings are more resistant to mechanical action unlike rigid crusts which get easily damaged.

The above chemical agents produce coatings, whose ageing and natural failure occur after three to four years of performance. In the case of coatings with rigid crusts this period can be shorter. The length of a coating effective performance allows the necessary time for crop growth and development when the plantings begin to play an anti-erosion and sand-stabilization role.

Plants of the Calligonum species have proved to be the most efficient phyto-meliorants of barchan sands in Central Asia. 80 to 90 per cent of these take root, having a survival rate of 60-70 per cent, while Haloxylon persicum Bg. and Haloxylon aphyllum (Minks.) Jijin are believed to be effective sand-binders at later stages of sand afforestation.

In the Soviet Union, various chemical agents have been used to stabilize thousands of kilometres of pipelines, in particular, the intercontinental gas pipelines "Bukhara-Urals", "Central Asia-Centre" and hundreds of kilometres of roads. Binding agents are widely used for barchan relief stabilization in the afforestation of sands.

Establishment of pasture shelter strips is an example of rational use of agricultural afforestation in raising the productivity of sand pastures.

In the low-productivity Central Asian pastures, shelter strips are established by different methods: wide and narrow pasture shelter strips, massive land reclamation with a view to setting up long-term winter pastures.

A wide-shelter strip method using Haloxylon aphyllum (Minkw.) Jijin presupposed the sowing of seeds into 25 m-wide ploughed up strips of land spaced at 150-200 m. The method can be recommended for areas with favourable forest-growing conditions, in piedmont plains featuring well-developed desert sand soils and a high precipitation level (180-200 mm).

A narrow shelter-strip method is recommended for the typical conditions of a sand desert. Here, it is thought appropriate to establish 25 m wide pasture shelter strips not by ploughing up the strip as whole; instead, five narrow 1.5 m-wide strips are ploughed up which is followed by row sowing of Haloxylon aphyllum seeds. It is recommended to space the narrow strips at 5-8 m. A narrow-strip system ensures preservation of natural vegetation on the unploughed sections. In the case of the side shelter-strip, natural vegetation takes 6 to 7 years to regenerate.

In the Central Asian sand deserts, pasture shelter strips increase the yield capacity of fodder crops in the inter-strip spacings by 14-16 per cent, which means that the pastures can accommodate 30 to 40 per cent more sheep.

The system of pasture shelter strips not only improves the condition of the grassland, it also protects the sheep in bad weather. Their protective function is important in summer, too, when afforested areas are capable of transforming any critical meteorological conditions, upsettting the sheep's normal physiological functions, to the desired optimum. This ensures a 10-18 per cent increase of meat productivity; raises the survival and safety of sheep youngsters by 8-15 per cent and wool shearing by 7 - 12 per cent (Vinogradov, 1977).

Extractive Industry

The deserts and semi-deserts of the Soviet Union store most essential mineral resources, on which basis extractive industry has been developed intensively during the years of Soviet power. This gave rise to a variety of industries and considerably changed the settlement pattern in the republics of Central Asia and Kazakhstan.

Kazakhstan has huge deposits of copper (Dzhezkazkan, Balkhash, Bozshakul), titanum, manganese, antimony. Unlimited salt reserves are in the Caspian and Aral Regions, in Central Kazakhstan. There are also considerable resources of construction materials. As these deposits consitute the basis of Kazakhstan's heavy industry, they are being successfully exploited. The problem of Kazakhstan's extractive industry development is that it is located in the desert and semi-desert zone, with characteristic lack of water supply, summer heat and low temperatures in winter.

Oil and gas are the most valuable mineral resources of all that are known to exist in the Central Asian deserts.

For years oil production was confined to Balkhash Region in the Karakums. Exploration of deposits of Neftedag, Kumdag and Boyedag was undertaken. Depletion of the secondary oil traps and the necessity of increasing the production of oil have called for advanced methods of stepping up pressure (water injection along and beyond contour, gas pumping) and required a search for new structures. These were found at Koturdepe (a high-yielding deposit situated between Nebit-Dag and Cheleken); at Okarem (gas condensate-oil on the Caspian Shore); at Barsakelmes south of Nebit-Dag; at Kamyshldja, south-west of Nebit-Dag and at Komsomolskoye, north of Koturdepe.

Koturdepe and Barsakelmes deposits are some of the largest in the USSR, the former being a major oil field. This, and the fact that oil there is produced by gushing make Koturdepe deposit different from others due to low labour expenses and low prime cost.

Thanks to the recently discovered deposits, the Turkmen SSR produces 4 per cent of the total oil extracted in the USSR (1974) and about 90 per cent of the oil produced in Central Asia. 4 per cent of the Union total may seem a small value, but one should bear in mind that the Turkmen oil meets the basic requirements of the entire Central Asian economic region. Besides, it is processed at Krasnovodsk and Fergana oil refineries and from there kerosene, petrol, fuel oil, diesel fuel are supplied to all the republics of Central Asia. The oil products cover the needs of industry and agriculture, including driving-pasture livestock farming. Desert development without modern transport, operating on oil products, would have been different and the rates of development would have been different as well.

Gas production in the Karakums and Kyzylkum began much later than production and use of oil.

There are a few gas-bearing areas, all of them in between the oil-bearing regions of the Central Asian deserts: Central-Karakum and Kyzylkum gas-bearing areas, Murgab and Amu-Darya gas-bearing areas and oil-bearing areas. In the Central Karakums, gas has been found in the vicinity of Darwasa and Zeagli.

Kyzylkum is famous for its deposits at Gazli, Mubarek Djarkak, Urtabulak, which supply gas for the republican needs as well as to the gas pipelines, laid to the Urals and to the Centre, and also to the neighbouring republics of Central Asia.

Murgab oil-and-gas bearing area includes a number of deposits, the largest being Shatlyk. This serves as the major gas supplier for the fourth stage of the Central Asia-Centre gas pipeline.

Amu-Darya gas and oil-bearing region includes deposits at Farab, Atchak, Naip, Saman-Tepe, Bagadja, Gugurtli. Atchak is the initial point of the Central Asia-Centre gas pipeline. It was later extended to include the Naip deposit.

Of all the above-mentioned deposits, those at Shatlyk, Atchak, Naip, Saman-Tepe, Bagadja are unique as far as their size is concerned. Gugurtli deposit is large. Shatlyk deposit happens to be one of the world's 10 largest gas-oil fields, its reserves estimated at thousands of billions cubic metres.

Natural gas from gas wells is used as fuel. It helps to run gas-turbine power stations at Krasnovodsk, Nebit-Dag, Bezmein, and the hydro-electric power station at Mary, the most powerful one in the Turkmen SSR. Population has become yet another gas consumer. Cylinder gas is now a routine source of fuel in any town, township and even in rural settlements. At the same time, gas supply is being provided in the towns, all power, communal and industrial facilities, including hot-water supply, are natural gas operated. However, the volume of gas extracted by far exceeds the local consumer requirements. This disproportion was duly taken into account and so as more new gas fields are discovered, more and more gas pipelines on republican, inter-republican and national scale are constructed.

Major republican gas pipelines are Kumdag-Nebit Dag, Koturdepe-Krasnovodsk, Maiskoye-Bezmein. Kyzylkum gas (Mubarek, Djarkak) is supplied to Tashkent, Chimkent, Frunze, Alma-Ata and a great many smaller townships scattered along the inter-republican gas pipelines routes. From deposits at Gazli and the Karakums, gas is supplied to the European part of the USSR over the Gazli-Urals and Central Asia-Centre gas pipelines. Shatlyk, Atchak and Naip deposits are essential for the supply of gas to the country's central areas, including Moscow.

Oil and gas extraction industry is the basis of 'big chemistry' development in the republics of Central Asia. There is a large centre of chemical industry in Bukhara Region turning out ammonium nitrate, liquid nitrogenous fertilizer, cellulose acetate. In the new town of Neftezavodsk, near Chardzhou, a petrochemical complex is now under construction to specialize in oil refinery and production of tyres. There are iodine-bromine plants at Nebit-Dag and Cheleken.

Central Asia ranks first in the USSR as regards its haloid and sulphate salt reserves, Kara-Bogaz-Gol being the major deposit of sulphate mineral salts. Mechanized production of salt is in progress on the shore of the Aral Sea.

The desert is rich in native sulphur. A large deposit of this mineral is located in the Gaurdak Mountains, the Turkmen SSR. This sulphur is used to operate a Chardzhou super-phosphate complex, producing phosphate fertilizer (phosphate rock is supplied from Kazakhstan).

Mineral and construction raw materials occur in the deserts almost everwhere in unlimited quantities. Of construction materials, limestone essential for cement production figures most prominently. The mining of a large Bezmein deposit of limestone and pebble is underway. Another well-known deposit of high-quality sandstones is at Bakharden, on the basis of which Ashkhabad glass works are operated. Strata of a wallstone are common in Mangyshlak, Oustyurt and at Krasnovodsk Plateau. This stone is used in many Turkmenian towns for housing construction.

Of metals, lead and zinc occur in the polumetallic ores of Kougitang, and gold in the Muruntau Mountains of Kyzylkum.

The development of extractive industry calls for increased production and consumption of electricity. Even now, Central Asia enjoys a centralized power network, which links all thermal and hydroelectric power stations. Among the stations currently in operation are those at Krasnovodsk, Nebit-Dag, Mary, Navoyi. In future, the power capacity will sharphy increase as the Nurek, Toktogul and Amy-Darya hydro-electric power stations reach their design capacity.

The sun and wind are increasingly used as power sources.

The fast rates of industrial development of deserts and semi-deserts have made transport a prerequisite. While the old railway crossing Central Asia was reconstructed, a new line was laid to link Guriev-Baynau-Kungrad with the town of Nukus; one more line is still under construction (Alexandrov Cai-Makat). First-rate motor roads have been built in the Karakums and Kyzylkum deserts.

As late as 1979, the population of the deserts and semi-deserts of Central Asia and Kazakhstan numbered 26.2 million. For the last 20 years (1959-1979) it increased by 83.2 per cent (USSR average, 21 per cent). While accounting for 10 per cent of the country's total population, the arid zone contributed 22 per cent of the USSR population growth for the same period.

The arid zone is peculiar in that its rural population steadily grows, hence the increase of demographic potentials for urbanization. Rural population increased by 62.5 per cent for the abovementioned 20 year period.

Nevertheless, the desert area attracts considerable migration flows from many other areas of the country, which accounts for ethnic diversity of the Central Asian urban population, the main migration crossroads being capital cities and newly built towns.

In the past, the dominant genetic pattern of arid zone urbanization was that they 'matured' from the rural areas. The towns used to be shaped as trade-artisan or religious superstructure of the rural environment, their non-economic functions being rather significant. Even today the towns frequently emerge from rural settlements in the areas of intensive agricultural development, but now the process has entirely different social and economic implications.

During the years of Soviet Power, the leading genetic lines of urbanization have become those of resource development, economic management and industry. an important peculiarity of urbanization in the arid zone, economically, is a closer relationship between agriculture and industry, and a rather high proportion of the townsfolks engaged in agriculture. A distinct urbanization feature here, as well as in the country as a whole, has been the formation of multi-functional large cities being economic headquarters of a particular area.

This is due, in the first place, to the active processes of political, cultural and economic consolidation of the socialist nations, to the changing way of life of the indigenous population, the enormous scale of resource development and economic transformation. The accomplishment of these tasks of great historical importance called for well-developed, powerful centres as bases for further development. Hence, the special significance of capital cities.

A combination of the natural historic and economic conditions predetermines a high concentration of population and economic activity in the areas more suitable for human life and activity.

The progress of science and technology makes it possible to expand considerably the number of areas for intense resource utilization (concentration areas). However, to achieve an economically efficient decision-making, it is essential that modern equipment and materials should be channelled to areas of maximum potential return. Powerful machinery is used, as a rule, to overcome serious handicaps, to fill a significant gap in the combination of conditions and resources of a particular area. For example, to alleviate the effect of extreme phenomena,to prevent natural calamities or eliminate their consequencies, etc. The whole mechanism of economic development somehow or other gets involved in the process. Thus, solutions to different problems were found: in the case of Mangyshlak resources development, an atomic reactor was used to desalinate sea water; water to the field of the Golodnaya Steppe was supplied by pump lift; large main canals – Karakum, Amu-Bukhara, Karshi, etc. – were built. The construction of the Karakum Main Canal in the Atrek Valley makes it possible to achieve an integrated development of this dry subtropical area, the only one in the USSR.

The contrasting economic conditions of the territory underlines the importance of all kinds of natural and anthropogenic features in the arid zone. Very essential here are such linear features of development as large rivers, sea and lake shores, main canals, transport routes, borderlines of mountains and valleys.

The concentration of population and economic activity, featured in the zone of contact between the mountaneous and plain parts of Central Asia and Southern Kazakhstan, has been particularly important in the macroterritorial structure of economy of the dry area. It is in the piedmont area that the main economic axis of the entire South-Eastern Region of the USSR has been formed historically, registering a full and multifarious growth in the Soviet period. The fields of the staple crop – cotton – are concentrated here; the intermingling transport routes from distinct polyroutes; there are chains and clusters of major towns. The active urbanization has increased the level of economic concentration, making even more clearly cut the settlement belt running along the main economic axis.

Outside this axis area, its shape rather intricate in itself, there is a multitude of minor centres in which productive forces are concentrated.

On the whole, the spatial progress of urbanization in the arid zone is determined by the following two factors:

1. Growing concentration in the main settlement belt. Here, urban and rural settlements are particularly close and interacting; complex urban agglomerations are formed.

2. Development of the increasing number of resource-oriented centres deep inside the arid zone, away from the main economic area.

As a rule, a multi-functional city is formed as a core of the most promising development centres. When such a city is given administrative functions to perform (this is common for the Soviet management practice whereby a city administrative rank corresponds to its economic status), it is in a better position to acquit itself of the administrative and economic tasks.

The establishment and consistent consolidation of such centres, forming the basic skeleton of the territorial economic structure is one of the most important features of arid zone urbanization. These are the centres of some comparatively recently established regions: Schevchenko (Mangyshlak R.), Arkalyk (Turgai R.), Dzhezkagan (Dzhezhazhan R.), Dzhizak (Dzhizak R.), Gulistan (Syr-Darya R.).

A regional centre, frequently surrounded by its satellites, forms the core of a new territorial economic entity, constantly undergoing the process of shaping. Also, there may be local groups of centres headed by a leading centre, although not in the rank of a regional one (Nebit-Dag, Karatau, Balkhash). A special category is constituted by the centres of mining industry (Zarafshan, Cheleken, etc.).

It is clear from the foregoing that the socialist approach to the utilization of natural resources consists in the realistic treatment of the desert's natural 'productivity' and in the possibility of its increase through reclamation and technological measures, rational use of natural resources with due regard to the territorial differences and economic efficiency. Such an approach is based on the State support of proposed measures, guaranteed financing, involving scientists and engineers in the realization of projects. A zealous treatment of nature is and always has been a corner-stone of our nature conservation policy.

This notwithstanding, there are instances of harm being done to the desert. Sometimes the damage is unavoidable, while in other cases it is the result of intensification of the most fragile eco-systems, desert and semi-desert areas, by people who either have no proper knowledge of or fail to consider the laws of their development; this may accelerate or further intensify the desertification process.

The scope of this paper does not allow to dwell on the natural processes of desertification in the republics of Central Asia, all the more so as their origin is open to debate. For this reason, we shall only consider some examples of the desertification anthropogenic processes.

It should be noted that prior to the 1977 UN Conference on Desertification the term 'desertification' was seldom used in Soviet literature. Common were such notions as 'pasture degradation', etc., all of which are included in the notion of 'desertification'.

Anthropogenic desertification encompasses all components of the natural environment, the rate of aridization, degradation of some components and suppression of others increasing sharply as a result of extended use of arid areas.

It is to be pointed out that desertification processes in the USSR are rather limited, have never been widely-spread and are not of a catastrophic nature. Their scale and intensity are different from those examplified in the Plan of Action recommendations.

Desertification processes used to be of high intensity in the pre-revolutionary period. In this connection, while developing the desert areas, measures to arrest further spread of these processes had to be considered.

After ages of arbitrary cattle pasturing by the population of the Khiva and Bukhara Khanates in the vast areas of Trans-Unguz and Eastern Karakums the sands were trampled out, and large barchan tracts were formed.

The so-called Khova Barchan Tongue stretched especially far to the south, along the ancient caravan route from Khoresm to Merve. As early as 1955, it was 75 km long. As a result of rational use of pastures, afforestation measures, gas service installation in human settlements, and consequential reduced cutting of Haloxylon as firewood the deflation processes slacked. The decisive role was that of the lake drain laid along the edge of the sands to divert irrigation drainage waters from Khoresm cotton fields. It was in the zone of intensive deflation that the underground water level went up, which increased the wind-erosion resistance of the sand surface and improved the afforestation conditions. So, what used to be barchan tracts are now slightly afforested sands, while the trampled sands have become semi-afforested.

There used to be a 250-km long barchan strip on the left bank of the Amu-Darya, extending from the Afghan border as far as Chardzhou. The origin of this strip can be related to the development of astrakhan sheep farming in the Bukhara Khanate. After the collectivization campaign in agriculture was over, a wide-scale construction of deep water-wells was undertaken in the rich grasslands of the South-Eastern Karakums, which attracted the sheep from the oases area. Later, phyto-reclamation measures were applied here, with Haloxylon planted in strips along the sand edge producing a very good result. The barchan strip survived only in the form of group and single barchans and barchan chains as well as barchaned hilltops scattered among shrub-strewn hillock sands. Barchan sands new account for about 10 per cent of the entire former Amu-Darya barchan strip.

In the past, the few dirt roads that were available were used for distant pasture servicing, with by-passes on the grade and broken sections. Thanks to the use of cross-country vehicles with wide-track, low-pressure tyres and road-construction machinery, as well as to repair and rehabilitation road works, the condition of the roads has been improved, and they have ceased to be a source of deflation. Old water-wells became more accessible and sheep populations more scattered, hence the reduced areas of water-well barchan tracts and trampled sands. A more rational pasturing has improved the wind-erosion condition of overused grasslands, with more new areas being added. In the north-eastern section of the Central Karakums, in the Trans-Unguz Area, the sheep have destroyed considerable tracts of desert moss, which substantially raised the yielding capacity of the grasses and revived the shrubs. Asphalt roads almost entirely eliminate undesirable contacts of machinery with nature, bringing new life forms to the desert.

Concentration of grassland sheep-farming around the few stock-drinking places in the Central Karakums encouraged the formation of water-well barchan tracts and the trampling of sands along the stock-driving roads. The construction of new water-well and laying water pipelines helped to scatter the stock, while the trampled sands are now consolidated with vegetation.

The construction of large-scale projects which radically change the existing ecological situation, involving huge areas, may bring about temporary negative consequencies.

In the course of the construction of the Karakum Canal, whereby a chain of new oases, over 1,000 km long, evolved, there formed tracts of trampled sands and sand pulp areas. Following water seepage from the Canal, and its systematic release on either side of the Canal, filtration lakes were formed, whose area is being gradually occupied by solonchaks (Kharin, Kalenov, 1978).

The area surrounding the Aral Sea can be considered as best representing the desertification processes. The steady reduction of the Aral Sea water surface, caused on the one hand by the regulated run-offs of the Syr-Darya and Amu-Darya, and on the other by an annual evaporation of an up to 1 m thick water layer, has resulted in the spreading of the desert over the vast delta areas of the Syr-Darya and Amu-Darya. The process is further aggravated by the disappearance of the delta natural environment. A sand-solonchak desert is being formed on the dried-up sea bottom, and this increasingly affects the rate and nature of the changes in the ecological situation in the Aral basin. With the size of this dry land constantly growing, a Kyzylkum-Aral-Karakum desert is being shaped, which may have far-reaching consequences for the natural environment and the processes in the adjoining areas. The consequences are largely unpredictable (Kuznetsov, 1980).

The problem of Aral desertification is likely to be solved by partial transfer of the Siberian river flows to Central Asia and Kazakhstan, which will enable us to manage the sea regime and to minimize the adverse effects on the environment.

The experience in the development of desert and semi-desert areas, accumulated in the Soviet Union and discussed in detail in this paper, certainly goes a long way to eliminate and prevent the desertification processes.

In the nearest future, the influence of man on the natural resources of the USSR desert and semi-desert areas will continue to grow. This is proved by the plans of further development of national economy in the republics of Central Asia and in Kazakhstan, envisaged by the 26th Congress of the CPSU for the 11th 5-year development plan period.

It is for this reason that even now the most important task of Soviet desert science consists in continued research of the desert process dynamics (monitoring) and in the scientific forecasting of the likely ecological consequences.

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REGIONAL OVERVIEW

Analysis and Synthesis of the Country Reports

The developing countries of the ESCAP region have a number of general similarities. They have proximity in space. Though there are marked differences among the countries and within them, they all are within the tropical and sub-tropical region. Most of the countries in the region share common historical experiences. For generations, historical developments in these countries have moved at a rather slow pace and even now the rate of change continues slowly (except for population). People in most of these countries are very poor and economic and social inequalities are high, notwithstanding the differences among individual countries.

All the developing countries in the ESCAP region have launched planned economic development through the overall supervisory and integrated effort of the national governments. The Plan of Action to Combat Desertification (PACD) envisaged that the individual governments would formulate programmes to combat desertification in accordance with the guidelines of comprehensive development plans at the national level. It is gratifying to state that all the reporting countries have indicated that PACD is being implemented as an integral part of national development planning and its execution.

At the national level, PACD is being co-ordinated and implemented in all these countries under the overall guidance and supervision of the national agencies. In some countries, such as Bangladesh, India and Pakistan, such machinery was already in existance, and in others such agencies have been established during the post United Nations Conference on Desertification (UNCOD) period.

Evaluation and monitoring of the areas affected by desertification have reportedly been initiated by all the countries. However, there appears to be a marked variation in the technical approach adopted by the individual countries. This could be explained partly by the emphasis devoted to the subject while reporting.

India has already completed an inventory of the basic natural resources of one third (90,000 sq.km.) of its arid zone. Pakistan has sufficient data on its soils and areas affected by waterlogging and salinity. Bangladesh has worked out details of the areas affected by the "hydrological quandary". The need for scientific land-use planning is recognized, but little seems to be done or implemented in the rural areas in most of the countries. This could be due to the following reasons:

(a) Inadequate scientific knowledge and technology; particularly in regard to an inter-disciplinary approach.

(b) The lack of transfer of science and technology to the rural areas.

(c) Shortage of technical manpower.

(d) Limited and inadequate public participation.

A transnational project on monitoring desertification processes and related natural resources in south-west Asia, covering four countries (Afghanistan, India, Iran and Pakistan), was recommended by UNCOD. As a follow-up action, the project document was presented at the First Meeting of the Consultative Group on Desertification which convened at Nairobi from 2 to 5 May 1978.

Although Iran had originally agreed to provide host facilities for the project, eventually this could not be implemented on a regional basis for a number of reasons. India and Pakistan have since initiated the monitoring desertification projects as national activities. Since Afghanistan and Iran had supported this transnational project throughout, it is assumed that the field work of monitoring desertification in these two countries has continued.

One of the main objectives of this transnational project was to enhance the capabilities and manpower training of the four individual countries of the region for combating desertification. Recognizing the importance of the project for implementing PACD and in view of the fact that the project could not be executed as originally conceived, it would be useful for the ESCAP workshop at Jodhpur to consider ways and means of implementing and strengthening the national monitoring project on desertification. The American Association for the Advancement of Science, which took the initiative of organizing a scientific seminar of "Indicators of Desertification" at Nairobi a week before UNCOD, might be interested, among others, in supporting the scientific aspects of the project.

Generally, it appears that mass movements to combat desertification, as in China, have yet to be initiated in most of these countries. "Desertification is a human phenomenon; it is more a social, economic and political problem than a technical one". Desertification is inherent in the human use of dry land resources and the societies in the region have the in-built capacity to cope with and absorb even significant degrees of desertification. Unless the magnitude of the losses in a given period is sufficiently serious to attract political attention, dry lands (and particularly arid areas) do not receive high priority and, in the absence of an overall long-term programme to combat desertification, whatever support is provisionally provided to mitigate the human hardship is ineffective and can be described as a palliative effort.

Public participation is one of the major measures of implementing PACD. The countries have initiated training and orientation courses for in-service personnel and in some countries farmers are also involved. Media are being used to create public awareness. Whether the efforts to enlist public participation are proportionately adequate to the seriousness and magnitude of the desertification problem is an open question. Public participation requires motivation. The national and international developmental projects in most developing countries generally cannot be claimed as unqualified successes. Frequently, the explanation is that people are traditional and their motivation is embedded in social structure. It has been stated that "planners plan for communities to which they themselves do not belong". This is not the place to go further into this matter, but suffice it to say that since human population may be considered as an integral part of the production system, its participation could perhaps be ensured by amending the administrative structure, incorporating elements of the society itself and providing the necessary incentives.[1] This question of public participation or mass movements is important for economic development of the ESCAP region. Its importance goes beyond the implementation of PACD. It is an important subject for the economic development of the countries involved.

Valuable information is included in the country report of the Union of Soviet Socialist Republics, presented to UNCOD and dealing with the changes in the eco-system as a result of the development of irrigated agriculture in arid regions. Along with the influences of irrigation on the physical and biological parameters, details are provided by the USSR on economic and industrial developments and related activities. The approach, the results reported and these studies are of great interest to the developing countries, where irrigation has been or is being introduced in the region (for example, the Rajasthan Canal Project in India).

The experience of Pakistan in successfully tackling the waterlogging and salinity problem and in obtaining increased crop acreage and crop yields should be valuable to other countries with problems of the same nature. The fact that desertification caused by waterlogging and salinity in irrigated arid regions can be combated successfully was the important contribution of Pakistan in the case study presented to UNCOD.

Irrigation provides the most productive basis for agriculture in arid and semi-arid regions. Estimates are that compared to rain-fed agriculture (dry farming), irrigated agriculture is at least four

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[1] B. Spooner, "Environmental problems and the organization of development in the arid lands of south-west Asia", Economic and Social Commission for Asia and the Pacific, 1979.

to six times more productive. It provides stability of production, thus removing risk and uncertainty. The green revolution achieved in some of the ESCAP countries by the application of high-cost inputs has been partly derived from the irrigated areas. The irrigated harvest area in the developing countries is increasing at a rate of more than 2.9 per cent per year in comparison with an annual expansion of 0.7 per cent in rain-fed areas. It is water, not land, that limits agricultural production in arid regions. Temperature is high, there is an abundance of sunlight and soils are generally good for crop production.

Irrigated agriculture, however, requires more skilled management and experience to exploit its full potential.

Irrigation systems are being introduced, for example, in western Rajasthan, India, where the local farmers do not have the experience and skill for irrigated agriculture. Earlier experience in Rajasthan has shown that it was not the local people who benefited by the introduction of irrigation, but the Punjab farmers who had the experience and skill and migrated to these newly developing areas because they were attracted by the irrigation facilities. Perhaps similar conditions exist in other countries. The country reports from the ESCAP region include limited information on the management of irrigated lands, extension work and training specifically for the irrigated areas.

Soil degradation resulting from water and wind erosion is an important factor causing desertification. To some extent, erosion influences 82 per cent of the ESCAP region as a whole, 90 per cent of northern and central Asia, 86 per cent of south-east Asia and 85 per cent of Australia.

Soil erosion occurs even in natural, undisturbed eco-systems, although on a small scale. But when the land is cleared of trees, shrubs and grasses, the rate of erosion is accelerated. The extension of cultivation in the mountains by clearing forests and adopting shifting cultivation or swidden agriculture is a traditional practice of the tribal communities in the forests. In 1966, it was estimated that about 266 million people over an area of 36 million sq.km. in the tropics practiced shifting cultivation. In the ESCAP region, about 80 million people in an area of 1.2 million sq.km are involved. Shifting cultivation and its consequent adverse effects have been reported from Indonesia, the Philippines and Nepal.

As a measure to implement PACD, a number of countries in the region are encouraging tree plantation and reforestation programmes, agro-forestry and related activities such as forestry education; extension campaigns are further efforts in this direction. Indonesia began the settlement of shifting cultivators in 1972 by means of certain incentives. India has initiated desert afforestation programmes as a part of its Drought-Prone Areas Programme. The Philippines, under its revised Forestry Code, has provided certain incentives to encourage reforestation. A Presidential Decree in the Philippines requires the planting of one tree every month for five years by every citizen above the age of 10. Thailand has declared five forest areas "Forest Reserves", constituting an area of 414 sq.km. Agroforestry programmes have been initiated in Nepal, Thailand, the Philippines and India.

Water is the main limiting factor for agriculture and animal-based production in the dry lands. The introduction of irrigation in these areas, wherever possible, has been the main approach in different countries.

The exploitation of the resources of these areas (with irrigation or otherwise) by mining, industrialization etc., has been responsible for their degradation. The USSR has significant experience in and technology for the reclamation of the degraded areas produced by such desertification processes. The USSR is offering training facilities to share its experiences and technology with the developing countries of the region (see below.)

Ground-water exploitation and its utilization for irrigation and livestock is another avenue to enhance water supplies. Quite frequently, ground-water is saline and not always suitable for crops or livestock. Till commerical desalination becomes feasible, such waters are of very limited value. Ground-water with a salt content up to 3,000 ppm suitable for livestock, can be used for salt-tolerant plants and crops, which can accept even higher concentrations. Studies are in progress to work out the safe limit for the utilization for such waters of questionable quality. Biosaline research may provide answers for the effective utilization of these ground-water resources.

The use of ground-water which appeared good for crop production is reported to have adversely influenced the soil chemical properties in Pakistan's Salinity Control and Reclamation Project (SCARP). Pakistan's case study presented to UNCOD also indicated the importance of water allocation to the farmers, individually and collectively. Pakistan's experience in ground-water utilization should be valuable for the countries of the ESCAP region, e.g. Bangladesh, India and Nepal.

Studies are reported to be in progress in India and Pakistan on soil properties and crop production as affected by saline water use.

It was envisaged that the immediate goal of PACD was to prevent and arrest the advance of desertification and to possibly reclaim desert land for production. The United Nations General Assembly resolution of 17 December 1974 decided "to initiate concerned international action to combat the spread of desert conditions".

A number of major recommendations for implementing PACD were, therefore, to be carried out in the arid and semi-arid regions.

Historically, in the arid regions, livestock husbandry (pastoralism) has been the major land-use system. Productivity per unit area is generally low, but because of the large proportion of the world's land area in arid or semi-arid (45 million sq.km.) zones the total contribution to food production is significant, besides providing livestock for a large population (600-700 million). In the ESCAP region, a high proportion of the countries' areas is mostly arid and semi-arid. In the south-west countries, namely Afghanistan, the north-west Indian plains, Iran and Pakistan, the arid regions have been inhabited by human populations for over 5,000 years. By arid-zone standards, the density of population in most of the countries is high, particularly in India (46 per sq.km). In the USSR, about 14 per cent of the territory is arid and semi-arid. A reference was made earlier to the notable success and achievements in development of the arid region by the USSR through the introduction of irrigation. India has adequate technology to implement the relevant recommendations of PACD, which are reportedly being utilized in its Desert Development Programmes and Drought-Prone Areas Programmes. But it appears that implementation over large areas is still limited in regard to a significant impact on productivity. Pakistan has recently established an agency for *Barani* (rain-fed agriculture) Area Development.

All the countries of the ESCAP region need to strengthen their national scientific and technological manpower resources. Therefore, steps should be taken by all the developing countries of the ESCAP region to strengthen and train their manpower in science and technology for their national development plan, with particular concern for implementing PACD. Assistance in the form of technical expertise to other less-developed countries is available from a number of countries, e.g. Australia, India and the USSR. A resource data base, including the use of remote-sensing technology, is being built up, which will provide an objective basis for economic development policies, the monitoring of human conditions, the rational utilization of resources consistent with the maintenance of the ecological balance, soil and water conservation etc. Some of these countries (Afghanistan, Bangladesh, Nepal) have indicated the need for support and assistance to their national efforts. A few activities initiated in the ESCAP region are as follow:

(a) An agreement between the United Nations Environment Programme (UNEP) and the USSR, signed in 1978, created a system of co-operation through international projects pertaining to environmental protection. Under this agreement, the USSR is arranging training courses in the reclamation of saline-irrigated soils, sand dune fixation, combating desertification through integrated development, ecology and management and productivity of range lands. The objective of these courses is to improve the professional skills of specialists of the developing countries of Asia, Africa, and Latin America. Within a period of two years (1979 and 1980) 115 specialists from the developing countries have participated in these training courses. An international symposium was being planned in the USSR in October 1981.

(b) As mentioned earlier, India organized an International Symposium on Arid Zone Research and Development in 1978 as a follow-up of UNCOD and the implementation of PACD. UNEP was represented in this international activity by a personal representative of the Executive Director and the Chief of the Desertification Unit. Another international symposium, "Anthropology and Desertification" was held at the Central Arid Zone Research Institute (CAZRI) at Jodhpur, India, in December 1978. An international training course on "Sand Dune Stabilization, Afforestation and Shelter-Belt in Arid Areas" was organized by CAZRI in March 1980 with the support of Food and Agriculture Organization of the United Nations (FAO) and the Danish International Development Authority Agency (DANIDA).

At the national level, CAZRI has organized a number of training courses in specialized disciplines related to arid lands improvement, such as "Desert Eco-system and its Improvement", "Arid Land Management", "Rodent Pest Management", "Integrated Resource Surveys" etc. In addition, a number of specialized institutions in India have organized training courses and symposia on subjects such as soil salinity, soil and water conservation, geological survey research of arid regions etc.

(c) In 1979, Pakistan arranged a national seminar on land and water resource development for *barani* (rain-fed) areas. It is difficult to judge how soon these measures and activities will start yielding results and making an impact on desertification problems.

Generally speaking, the action taken to implement the recommendations of PACD on socio-economic aspects seems to have attracted relatively less attention by most of the countries of the ESCAP region. Each country of the region has a population policy and family planning programmes. Data on economic and related aspects are being obtained by various agencies and departments of the national governments.

One of the reasons for limited action on these aspects so far could be that no specific department or agency in the countries is individually responsible for implementing the socio-economic aspects of PACD. Moreover, progress in the social sciences generally has been relatively slower than in the physical sciences. A point relating to inadequate public participation was made above.

All the countries have shown concern for the need to conserve conventional sources of energy. Reforestation and afforestation programmes have been initiated. Areas for tree planting have been identified and work is in progress. Use of biogas, though limited, has been started in India and Pakistan. India has designed a number of solar energy utilization devices for water heating, domestic cooking and drying of agricultural products; large-scale commercial fabrication of these devices and demonstrations are reported to be the next step.

It may be recalled that energy problems have a special significance for the ESCAP region. With the exception of Iran and probably China, most of the Asian countries do not have adequate oil or natural gas, and coal is unevenly distributed, involving problems of transport over long distances within a country such as India. The natural gas potential of the region is about 13 per cent of world total. Australia, China, Iran and Pakistan have a major share of this natural gas reserve, with smaller amounts in other countries.

It appears that fuelwood and agricultural wastes will continue to be the major sources of energy for domestic use in the ESCAP countries. Fuelwood requirements of the countries, estimated at 600 million cu.m. for 1981, are expected to rise to 765 million cu.m. by 1991. There is likely to be a deficit of about 125 million cu.m., which can be managed with adequate forestry policies.

As recommended by UNCOD for implementing PACD, a number of countries in the ESCAP region have established national machinery to plan and support the national programmes for combating desertification. In some of the countries, as for example India, a Desert Development Board was established many years ago.

For implementing PACD, a few recommendations were made by UNCOD for regional and international co-operation.

ESCAP sent a mission to Nepal for technical support of the country's implementation programme of PACD. A number of countries have indicated their willingness to have technical and financial assistance from United Nations agencies. A mention has been made above regarding training in integrated regional planning by the USSR and organization of symposia by India and Pakistan.

There appears to be an immediate and pressing need for regional co-operation in land, soil and water planning and management in the lower Himalayan region of the Indian sub-continent, including in particular shared international rivers.

Summary and Conclusions

Review and analysis of the country reports reveal that in the countries of the ESCAP region, desertification phenomena are encountered in four distinct environmental situations and land-use systems:

(a) Desertification occurs under pastoralism, in the arid and semi-arid areas where irrigation has not been introduced. In large areas of China, India, Iran, and parts of Afghanistan and Pakistan, pastoralism is the traditional land-use system in dry lands. The resources have been over-exploited, particularly in regard to vegetation, as a result of the increasing human and livestock population. China has made significant progress in combating desertification in considerable areas of the arid regions by the application of traditional knowledge and experience and large-scale public participation. In India and Iran a number of programmes are in progress for the reclamation of such degraded areas, to improve their productivity as a part of the action for the implementation of PACD.

(b) The introduction of irrigation in the arid regions of Afghanistan, Pakistan and the USSR has caused waterlogging and soil salinity, resulting in degradation of the biological productivity of the affected areas. The USSR has successfully reclaimed and developed large areas affected by salinity. Pakistan has successfully attempted reclamation, and this activity is being strengthened as a part of the overall development plans of the country. Afghanistan has initiated a few activities for combating desertification for areas affected by salinity.

(c) Degradation of the environment and land productivity as result of deforestation is reported from Indonesia, Nepal, the Philippines and Thailand. Shifting cultivation or swidden agriculture is a common practice followed by tribal communities in these countries, which adversely affects the eco-system. In recognition of the seriousness of the problem, action has been taken on the implementation of the relevant recommendations of PACD by these countries. Since the results and impact of the afforestation programmes take a long time, the size of the programme and the coverage of the area should have been larger than that which appears to have been taken up. Thus, Afghanistan and Pakistan have desertification problems both in their dry land regions and in the areas where irrigation has been introduced.

(d) Bangladesh has desertification problems resulting from what is called the "hydrological quandary", the country has initiated a number of programmes to implement PACD.

Some of the countries (for example, Afghanistan and Pakistan) have desertification problems caused by different factors and processes. Deforestation and its adverse effects are also common in a number of countries, but their extent varies considerably between the countries.

The countries have identified the factors causing desertification under different environmental conditions and action as a part of the individual country's development plans has been initiated. The scale of the programmes appears limited; inadequate finances and technical manpower appear to be the main limiting factors.

One of the important recommendations of PACD is to evaluate, assess and monitor resources and desertification. For the ESCAP region, a "Transnational Project to Monitor Desertification Processes and Related Natural Resources in Arid and Semi-arid Areas of South-west Asia" was planned for implementation as a regional project. For various reasons, this project could not be implemented on the regional basis as originally envisaged. India and Pakistan have initiated national projects to monitor desertification. It would be useful if ways and means could be worked out to achieve the main objectives of the transnational project as originally envisaged, for the finalization of which so much thought and effort were devoted by the various countries (Afghanistan, India, Iran and Pakistan) and UNCOD. In this context is may be mentioned that PACD presented a set of recommendations for initiating and sustaining a co-operative effort on the scale required to combat desertification. UNCOD hoped that "this co-operative effort should reinforce and integrate national, regional and global international action against desertification". The country reports or other readily available documents do not adequately reflect the continuation of this spirit or its reflection in the implementation of PACD.

An important general theme of PACD is that all measures are to be directed primarily towards the well-being of the people affected by desertification. Efforts to combat desertification are to be consistent with an integral part of national economic development planning and projects. There is a tacit assumption in this general theme that national development plans have been an unqualified success and have achieved the desired results and goals. Some of the countries of the ESCAP region have now had experience of development planning and its implementation for over three decades. In the developing countries, "the process of development has been a long tale filled with the tragedy of disappointments, rather than a success story". This may be a sweeping statement, but does point to an important need: to identify the factors responsible for the failures; these factors may range from inadequacy in realistic and effective planning to the lack of efficient implementation of planned projects and programmes, including PACD. PACD recognized that public awareness and participation are very important for the successful prevention and combating of desertification. Though the country reports do mention, with varied emphasis, the programmes for creating public awareness and involving people in the implementation of PACD, there is a need for intensifying these programmes. In Bangladesh, the response of the public and its participation appears encouraging. This matter of motivating people and ensuring their participation is extremely important in the developing countries. It permeates beyond the implementation of PACD and needs in-depth study and discussion.

The disaster produced by drought in the Sahel (1968-1973), causing human misery and suffering, focused global attention and led to UNCOD, which finalized PACD. One central theme during the debate of the Conference which runs through the recommendations of PACD is the seriousness and urgency with which the recommendation should be implemented. It was agreed that action must not await complete knowledge about the complex situation. The need was "recognized for immediate action in applying, existing knowledge" to combat desertification. UNCOD agreed to the goal of implementing PACD by the year 2000. A seven-year period (1978-1984) was earmarked to implement the immediate action required.

Against this back-drop of the seriousness of the problem and the urgency in implementing PACD, the governments were to take remedial and preventive action against desertification and integrate this action with national development plans and priorities. The action taken as reported, to implement PACD, by these 11 countries inadequately reflects the seriousness of the problem or its urgency. The speed and scale of the action taken appear limited. One is, therefore, left with a lurking doubt as to whether by the year 2000, PACD will be fully implemented. Let us hope that the actual situation is better than what has been possible to assess from the country reports and that mankind will be relieved of the menace of desertification by the year 2000.

ANNEX

Statement Summarizing the Implementation of PACD by Some of the Countries of the ESCAP Region

	Bangladesh	India	Indonesia	Nepal	Pakistan	Philippines	Thailand
Evaluation of desertification and land management							
1. Assessment and evaluation	In progress and studies initiated	In progress since 1959	–	In progress since 1974	–	Work initiated	–
2. Land-use planning	Studies initiated	90 000 sq.km. studied	Planned development in progress	Inprogress	–	Land improvement work started	Action initiated
3. Public participation	Public participation in the Food for Work programme and canals etc., undertaken	Receiving due attention	–	Educational work started	Education and training in progress	–	–
Industry and urbanization							
4. Industry and urbanization	Monitoring of urban industry in progress	Being looked after by Town Planning Departments	Industry yet in its infancy	–	–	–	–
Corrective anti-desertification measures							
5. Water resources	In progress	Adequate attention; scientific support being developed	–	In progress	–	–	Watershed management work started 1965
6. Range land and livestock management	Not applicable	Technology available and being implemented for development	–	Initiated	–	–	–
7. Soil and water	In progress and strengthened	–	–	Studies started	Agency established	–	–
8. Irrigated land	Measures being adopted	Limited problem yet in arid zone	–	Problem limited	In progress for the last many years	–	–
9. Re-vegetation of moving land	Afforestation work being strengthened	Programmes in progress	Reforestation and greening programme launched	In progress	–	–	–
10. Flora and fauna	Due attention being paid	Desert National Park established	–	National park established	–	Afforestation in progress	Alread being implemented
11. Monitoring arid lands	Proposed initiative by UNEP/ESCAP	In progress since 1970s and strengthened	–	Analysis in progress	–	–	–
Socio-economic aspects							
12. Man-made factor analysis	Analysis initiated	Studies in progress	–	Analysis in progress	–	–	–
13. Economic and demographic policy	Population control and rural development programmes in progress	Policy exists and being implemented	–	–	–	–	–

ANNEX

Statement Summarizing the Implementation of PACD by Some of the Countries of the ESCAP Region

	Bangladesh	India	Indonesia	Nepal	Pakistan	Philippines	Thailand
policy	progress						
14. Health care	Being attended	Sufficient facilities exist	–	–	–	–	–
15. Construction avoidance	Will be considered when contingency arises	Already being implemented	–	Action taken	–	–	–
16. Human condition monitoring	Being taken care of	Anthropological, social and census information	–	Base line surveys being undertaken	Socio-economic studies in progress	–	–
Drought risk insurance							
17. Preventive measures against drought	Food insurance scheme advocated	A number of development projects in progress	–	Emergency food assistance provided	A special agency established	–	National committee set up
National science technology strengthening							
18. Rational resource utilization	Co-operating with all countries	Being implemented and further strengthened	–	National council established 1976		A futuristic land-use plan prepared. Priority to education	
19. Non-conventional energy source	Biogas, natural gas, solar energy being developed	Due attention being paid and efforts made	–	Under consideration	Research initiated	–	
20. Training and education	Priority being given	Being implemented and is being planned	–	Being undertaken	Action initiated	–	–
21. National Co-ordinating machinery	Established	Already exists	–	National agency established	A national committee established	–	Established
Integration of anti-desertification and national development plan							
22. Integration	Implemented	Implemented	–	–	–	–	–
23. International action and support	Very much inclined	–	–	–	–	–	–
24. –	Not applicable	–	–	–	–	–	–
25. –	Not applicable	–	–	–	–	–	–
26. Judicious use of shared water resources	Pursuing this policy. Has relevant proposals	–	–	–	–	–	–
27. –	Will actively participate	–	–	–	–	–	–

PART IV

TOPIC REVIEW

I. MONITORING AND ASSESSMENT

A. Technology of Soil and Water Conservation in Arid and Semi-Arid Areas*

Introduction

The regression of vegetation under arid and semi-arid conditions leading to an irreversible reduction of plant cover can be described as "desertification". Desertification occurs essentially along the margins of deserts or where rainfall is between 100 and 200 mm per annum. Desertification results from a combination of factors but the basic cause is the impact of man and his livestock upon the land. As a consequence of constantly increasing demographic pressure (in some countries of the region population growth is in the order of 3.5 percent per annum) there is bound to be destruction of vegetation for use as small timber, firewood, fencing, etc. The gathering of ligneous forage species for firewood accounts to an alarming extent for the advance of the desert in the arid parts of India, Pakistan and Near East. Overgrazing as the herd of cattle increases and the expansion of cultivated land to produce even more cereal crops to feed growing numbers of people are direct consequences of demographic pressure. As population and livestock density increases beyond the carrying capacity of the natural resource an irreversible reduction of the resource itself occurs. Over the years, in different parts of the world, many solutions have been put forward to conserve soil and water in arid and semi-arid areas and to prevent desertification. This paper attempts to briefly review the technological solutions practised to serve as a starting point for exchange of information on these aspects at this forum.

For convenience of presentation, the technical solutions adopted in arid and semi-arid lands can be grouped as those relating to problems of:

(a) Range management
(b) Shelterbelt establishment
(c) Sand dune stabilization
(d) Increasing the availability of water (3)

Range management

In areas of low and uncertain rainfall where cultivation of agricultural crops is risky, pastoral pursuits are most common. In arid and semi-arid environments, if grazing practices are not rationalized, over-use of the range will result in the removal of vegetation cover followed by accelerated run-off, increased erosion and reduced productivity. Good range management should, therefore, aim at preserving the native perennial vegetation cover and create conditions of stability and productivity of the landscape.

Almost the first step in the long and arduous process of rehabilitation of despoiled ranges is to take land, at least temporarily, out of use and to create range reserves with strict protective measures. The environment reacts very favourably and fairly rapidly to such measures and in several countries (e.g. Syria, Mauritania) impressive results have been observed in the experimental reserves that have been so set up. Important among the measures designed to improve range management are manipulation of grazing through practices such as "deferred grazing". In Western Australia, the return of edible perennial grazing species has been promoted by deferred grazing coupled with judicious dry season burning of spinifex which dominated the pastures (10). Whereas uncontrolled fires can cause serious damage to pastures, fire can also be used as a valuable management tool to remove coarse, unpalatable materials while managing perennial grass lands.

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* Prepared by FAO Regional Office for Asia and the Pacific, Bangkok, Thailand.

In severely degraded areas where the top soil has already been removed together with grazing manipulation it would be necessary to carry out re-seeding and cultural operations aimed at increasing water penetration providing a seed bed and reducing wind velocity at ground level. Aerial seeding could be attempted to speed up the spread of more productive perennial species amongst established lines of vegetation or in areas carrying natural annual species. Thus the broad approach in range management involves progressive fencing, grazing control and large-scale pasture re-establishment. Spectacular results have been achieved in re-establishing vegetation on formerly bare Ord River catchment area in Western Australia following a massive cultural and re-seeding operation. It has been reported (4) that the greatest single factor in the success so far achieved here is protection from grazing – over 45,000 heads of cattle and some 30,000 donkeys have been removed from the areas under treatment. It was observed in Ord River catchment that rehabilitation of degraded range land is a gradual process. In many cases top soil conditions will have to be ameliorated before vegetation can be re-established. Regeneration proceeds at a slow pace through a gradual plant succession from the "pioneer" annual species through to the permanent and more productive perennial species needed for a stable catchment area. Grazial control followed by re-seeding proved to be the best available technique.

A useful technology that can be adopted in order to maintain soil fertility in the crop-raising zones that fringe the arid areas is to raise forage crops, in particular legumes in rotation with cereals or industrial crops. Among the species which found success in the Mediterranean as well as the tropics are: *Stylosanthes humilis, Dolichos lablab, D. biflorus, Vigna sinensis,* lucerne, bersim and Persian clover. These crops have been grown successfully in areas with from 400 mm to 800 mm rainfall. They provide extra feed to cattle and lessen the pressure on range lands under protection.

The re-sowing of grasslands have also resulted in some successes in USSR and Tunisia where large-scale plantations of forage trees and bushes have been established (6). The planting of drought resistant spineless acacias can be practised in areas of less than 150 mm rainfall to successfully increase the availability of edible dry matter. Plantations of *Acacia cyanophylla, A. ligulata, A. salicina, A. aneura, A. victorial, A. nummularia, A. halinus and A. albida* have been tried in Tunisia, Israel and Sahel with varying degrees of success. A key factor in successful range management is the degree of protection that is afforded to the plantations in the initial years (2 to 5 years) and the careful utilization afterwards to prevent the disappearance of the vegetation due to overgrazing.

The growing of wood lots near villages to meet the local small timber and fuelwood needs will supplement the efforts at conservation and management of the ranges being established in the arid and semi-arid areas. Foresters, over the decades, have successfully compiled lists of species useful to the villagers and which can be grown with relative ease on appropriate sites in areas with as little rainfall as 150-200 mm. Some of the wood lot species suitable for the tropics are *Tamarix aphylla, T. nilotica, Eucallyptus microtheca, E. crebra, E. camaldulensis, E. rudis, E. tereticornis, Acacia nilotica* spp. *indica, A. albida, A. senegal, Prosopis chilensis, P. cineraria, Azadirachta indica, Dalbergia sissoo, Khaya senegalensis, Albizia lebek, Cassia siamea, Anogeissus leiocarpus* and *Parkia clappertoniana.* The limiting factors to achieving success in this area are not of a technical nature, but rather social and political. The major task is to organize and motivate the pastoral people by a mixture of incentives and firmness. In almost every country the need for appropriate institution-building, the organization of rural communities to take care of the range and the exercise of technical control by appropriate government agencies are seen as important prerequisites for successful range management.

Shelterbelts

In arid and semi-arid areas in order to moderate wind velocity, reduce evapotranspiration, and thereby protect crops from wind damage shelterbelts and wind-breaks have been raised in different parts of the world since the middle of 19th century (2). It has been amply demonstrated by experience so far gained that shelterbelts and wind-breaks improve the micro-climate, reduce erosion and increase agricultural yields. As a devise to combat wind erosion they are effective under harsher conditions of arid lands. However, their establishment can be particularly difficult and financially costly in the arid areas. It is the crippling initial outlays combined with considerable risk of failure which has so far prevented the developing countries of the region from undertaking raising of shelterbelts and windbreaks on an extensive scale. Correct choice of species and adoption of appropriate techniques of establishment and maintenance could yield higher economic benefits and make shelterbelt raising a remunerative practice.

Design of shelterbelts

In the design of shelterbelts the major aim is to achieve a reduction in wind velocity on the windward as well as leeward sides using the minimum possible land area. They can be designed to be compact or windproof, they can be permeable (allowing about 30 per cent air flow) or porous (allowing 40 per cent air flow).

When the shelterbelt is impermeable to wind, all the flow is deflected upward, over the belt, leaving a reduced wind zone downward. It provides a greater degree of shelter immediately to leeward, but because of eddying effect, it gives comparatively short zone of effective shelter. To achieve appropriate reduction in wind velocity, shelterbelts should ideally be permeable with calculated width, shape and height.

Permeable and porous shelterbelts are obviously more economic to establish and although they provide less absolute reduction of velocity they do affect a greater distance downward. The vertical structure of shelterbelts depends on the form of tree species, the number of rows, the distance between rows and the number of trees within rows. In regard to wind speed reduction, the thickness of a shelterbelt is of secondary consideration. Narrow shelterbelts of moderate density are as effective as broad ones. For example: *Eucalyptus camaldulensis* can form a permeable screen even with two rows. In practice, the width of a shelterbelt is determined by the area of land which could be economically devoted to planting. In semi-arid or humid (non-irrigated) areas five-row shelterbelts are generally efficient and economic to establish and maintain and do not take up much area (1). They should be as narrow in thickness as practicable at the same time affording the required density at all levels. Single row shelterbelts seldom serve the purpose since they are likely to develop gaps. Shelterbelts with two rows are recommended for arid areas where they can be successfully established only with the aid of irrigation. They should be established along major farm boundaries at right angles, or at angles of no less than 50° to prevailing wind direction. If the winds are from various directions, a chessboard pattern should be used, with principal belts across the primary direction.

The zone of wind velocity reduction from the belt normally is expressed in multiples of shelterbelt height. The principal shelterbelts are generally separated by a distance equivalent to 20 times the height of the tallest tree (1). Thus a spacing of about 200 m to 300 m between shelterbelts is desirable in arid areas where tree heights seldom reach beyond 10 m to 15 m.

When the purpose of the shelterbelt is to provide shade to livestock during hot seasons it is recommended that scattered tree plantations in configurations such as "V" or "U" with open end of the "V" and "U" downward may be established (1). To protect farm houses, buildings, etc., shelterbelts should be designed to be permeable (dense shelterbelts placed too near buildings can result in oppressive heat during summer) and be located at least 30-45 m but not more than about 90-120 m from the buildings to be protected (1).

Wherever shelterbelts are to serve the purpose of arresting drifting sand it is desirable to establish a first windward row of low-crowned trees or shrubs such as *Prosopis juliflora*, *Parkinsonia* sp., *Tamarix* sp., etc.

Planting techniques

Adaptability to the soil and climate of the area are the prerequisites for selection of species for shelterbelts. It is desirable that the species selected be quick growing and wind firm with dense crowns. Preferably trees and shrubs should be evergreen and resistant to drought and disease; whether indigenous or exotic they should grow best in the locality concerned. Trees frequently used in arid tropical climates of the region are: *Acacia* spp., *Azadirachta indica*, *Casuarina equisetifolia*, *Cupressus macrocarpa*, *Dalbergia sissoo*, *Eucalyptus camaldulensis*, *Parkinsonia aculeata*, *Ziyphus spina-christi*.

To achieve fast growth and higher survival, as a first priority, shelterbelts should be established near irrigation channels or in special ditches dug along the banks of the field channels. Planting site preparation is more critical for a shelterbelt than for conventional forestry plantations since high seedling survival, rapid growth and development of good tree form are desired. Soil preparation to a depth of 40 to 60 cms. over the entire strip is recommended. Where impermeable hard-pans are encountered they should be broken, if necessary by deep ploughing. Planting of nursery grown container seedlings, use of portable pipes and mobile tankers to ensure irrigation will improve chances of survival and growth. Once established tree growth can be augmented considerably through effective maintenance: regular weeding (even use of weedicides) and soil working to conserve moisture.

In order to eliminate root competition by trees to agriculture crops, vertical root pruning is recommended and can be carried out most effectively by digging trenches parallel to the shelterbelt. A regime of thinnings and selective removal of rows of trees within shelterbelts (always ensuring that at least one row is left standing) should be practised to ensure effective protection of the crops. The cutting cycle depends on the species, their growth rates and protective effectiveness. As a rough estimate, the cutting cycle of most species in arid zones is 15 to 25 years (2).

In the arid areas of the region there is need for intensifying location specific research to determine the design and structure of shelterbelts on different soils, methods of management to ensure optimum protection and reduction of negative effects on crop production.

Sand dune stabilization

Soils of sand dunes are characterized by low moisture retention, high porosity, high infiltration capacity and good aeration. The potential for tree growth on sand dunes depends on the fertility of the sand, the fertility of the substratum, the depth of the sand deposits and the groundwater level. Before afforestation the moving sands need to be stabilized. Four common methods of dune stabilization as summarized by Jensen (5) are:

(a) *Fore-dune principle.* Artificial dunes are created with fences gradually built upon each other on the sand accumulated by the preceding fence. This method is often of a source of sand (e.g. desert area or sea) to check the transport of fresh sand to the area to be stabilized.

(b) *Micro-windbreaks.* These are fences or palisades about 0.5 m high laid out in parallel lines – if there is only one prevailing wind direction, or in chequer-board pattern if there are several. The distance between the fences varies between 4 and 20 m according to the fence height and the condition of the particular dunes. In arid and semi-arid zones it is recommended that only dead plant material should be used for the micro-windbreaks to avoid competition later with the trees (where afforestation is the objective). In humid tropics, on the contrary, dead plant material may house noxious animals, therefore living hedges are recommended.

(c) *Chemical mulching.* Because of the labour-intensive nature of making palisades and the difficulty of finding plant material for the micro-windbreaks, some countries have made use of chemical mulching (i.e. sprays), especially petrochemical products. These stabilizing materials have been developed from asphalt-type materials, latex and other chemical substances. They are typically diluted with local water and sprayed. Several commercial products are available. To generalize, the afforestation results from chemical mulching seem less successful than after traditional micro-windbreak type of fixation; however, results are largely dependent on application rates and methods. Combined with the seeding of grasses, petrol mulching has given excellent results in some cases. Whether chemical mulches are economical or not depends on the costs of these products in the particular country in comparison with the savings made on labour costs.

(d) *Revegetation.* Revegetation with grasses can be done in many cases without previous stabilization by using rather dense slip-plantings. This is the way in which most coastal dunes have been stabilized in temperate zones. Experimental work also has been carried out for direct seeding in conjunction with mulching.

Planting techniques

In general sand dune afforestation does not require soil preparation. A key factor in achieving success with dune afforestation is "deep planting" – because of a combination of rapidly dessicating surface layer and permanent moisture content at greater depths. Using container plants about 80 cms tall placed with the root collar in a depth of about 40 cms. leaving 40 cms. of the top in the open was demonstrated as a suitable technique in many areas. In arid and semi-arid zones direct sowing of tree seeds on sand dunes has generally failed. Proper stabilization followed by sowing of grasses and leguminous plants was, however, practised in some areas. Consolidation of seed beds by spraying with petrochemical materials after sowing could be an economic solution in countries where petroleum by-products are available and labour is costly. In most countries deep planting of fast growing species (such as *Acacia cyanophylla, Eucalyptus camaldulesis*) in container plants is still the most effective means of stabilizing shifting dunes and afforestation. In some countries deep planting with 1-2 metres long cuttings of Tamarisks or poplars in holes dug with soil augurs proved successful. Usually planting on sand dunes is carried out by notching with a special spade, taking care to see that the holes are made instantaneously with the planting operation to conserve soil moisture. Plant spacing depends on climate: 5 m between rows and 3 m between plants in the row is recommended for arid zones. Nothing general can be said about the requirements for fertilizers on dune afforestation although lack of nitrogen seems to be a common feature on sand dunes. Under arid conditions, use of fertilizers may have no effect unless combined with initial irrigation (5).

Increasing availability of water

In the semi-arid areas of the region a primary concern should be to improve water yields both in space and in time. Harvesting surface run-off of water is an ancient technique used to provide water for small agricultural operation, stock use or domestic needs. In Mexico extensive research is being conducted on water harvesting systems and active work in the past two decades has been carried out in Israel. A technique well known in many countries of the region is to dig ponds to catch rain.

The techniques used for collecting run-off water in semi-arid areas are several. The practice of strip farming by erecting berms or terraces along the contour with the area between them prepared to serve as a precipitation collection area can be effectively used in developing countries of the region.

Soil preparation in micro-catchment areas with one or several plants grown on the lower side is another water harvesting technique. Naturally impermeable surfaces such as tork outcroppings may be used as low cost water harvesting surfaces. Simple earth smoothing and compaction is sometimes effective. Concrete surfaces, sheet metal, fibre glass and polypropylene matting saturated with asphalt, plastics and tar paper covered with a layer of gravel, artificial rubber membrances are some of the most effective types of catchment surfaces used to catch water. In Australia, the "roaded catchment" is used, where catchments are graded and rolled to shed water. Rainfall quickly goes to the side of each "road" where a ditch carries it to a storage tank, usually also equipped with a silt tap (7). A complete run-off system should also include a means to store the collected water, such as excavated ponds or tanks of steel or concrete or any other impermeable material.

Conclusion

Experience with measures to combat desertification has shown that even if known and applied, technical solutions by themselves cannot solve the problem. In arid and semi-arid situations where natural resources are severely limited and population growth potentially infinite, sustainable solutions which balance the supply of goods and services from natural resources with the demands exerted by the population, should necessarily be multi-faceted, simultaneous dynamic and long term in nature. Their application depends on political and social will of the people concerned and would encompass a broad spectrum of activities which go beyond the identification of mere technical solutions. Since people's behaviour, attitudes and values are at the core of the environmental problem in arid and semi-arid areas, as elsewhere, much more attention must be given to understanding them and relating them to the physical world. Institutional structures and responses must be analyzed with a view to creating innovative approaches which deal with cross-sectional problems and conflicts. Soil scientists, agronomists, hydrologists and foresters should work with education specialists, sociologists, economists, extension agents and politicians to establish patterns of organization, administration, management and technical control which are practical and can be practised within present structures. Clearly the insights and perspectives of most scientific and professional disciplines should constitute an integral part of an overall environmental strategy, if the problems encountered in field of soil and water conservation in arid and semi-arid areas are to be resolved satisfactorily.

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B. Monitoring of Desertification*

I. Why Monitoring?

Desertification is a phenomenon dynamic in time, space and intensity. Nowadays it is moving fast, leading to an extension of barren land areas subjected to desertification, which consequently results in a reduction of agro-food production.

Considered from this viewpoint, monitoring is an absolute necessity, as it makes it possible to evaluate the evolution of the phenomenon in relation to time and space.

Its action is developing at two different, but complementary levels:

- Firstly as a means to enlarge our knowledge and understanding of the processes, their causes and evolution.

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* Prepared by C. Torres, Groupment from le Développement de la Télédétection Aérospatiale (GDTA).

Secondly, being so to say a warning system, it allows an early detection of the areas just contaminated as well as the identification of causes unknown up to now. Sometimes it casts a light on fast acceleration of desertification in some areas, as a result of modifications generally due to the action of men.

Remote sensing by satellite or aircraft which allows to perform a number of observations per year, and more so the Automatic Data Collection System which allows to collect information from 6 to 12 hours every day, make possible the early detection of any anomaly in the development of a project and the application of required modifications before irreversibility is reached.

II. What Should Be Subjected To Monitoring?

Desertification is a global process involving all the active factors, including man, prevailing on the earth's surface.

A conference organized by the American Association for the Advancement of Science, which took place in connection with, but apart from, UNCOD in 1977, summarized the desertification factors under three headings, namely:

- Physical factors : climate, soil, water, relief.
- Biological factors : natural vegetation and farming, animals, – especially cattle.
- Social factors : population growth pressure, land use modes, farming techniques.

Modern monitoring means can provide useful information on each of the three above mentioned groups.

It is obvious that the study of the physical factors and of vegetation represents monitoring preferential application fields, as it can take advantage at the same time of the cartographic and statistic methods as a working basis applied to these themes.

In addition, thanks to the Automatic Data Collection System (DCS), all the studies on census taking, on animal transhumance follow-ups, on human moves and on various other information, veterinary, social or economic, will take advantage in the short run of this modern follow-up means.

A detailed review of the phenomena which come within monitoring possibilities over a region as extensive and complex as Asia, is a long and critical task requiring a team of experts specialized in monitoring on the one hand, and most familiar with the various desertification types prevailing in Asia and in each of concerned geographical regions on the other hand.

III. How To Monitor? : Modern Tools Of Monitoring

Remote sensing

Remote sensing covers all the observation techniques of the earth's surface performed from aircraft and satellites, taking advantage of the electro-magnetic spectrum characteristics to collect said information.

Remote sensing incorporates data processing techniques applied to collected data whether they be photographic or plain information for data processing. The interpretation of such data is the subject of a specific scope requiring at the same time a thorough knowledge of remote sensing techniques and of the scientific application fields (namely agriculture, geology, etc....)

Aerial photography, historically much older than remote sensing, is now an integral part of the whole remote sensing means.

The necessary complementary nature of remote sensing means often remained restrained in numerous countries as a result of the historical connection of aerial photography and cartography, the latter being frequently kept under military status.

With the advent of high resolution satellites, such as SPOT in 1984, these barriers should be easily swept away. Some countries are already building up such a synthesis. India, for instance, avails herself simultaneously of Landsat receiving station and of airborne facilities.

Aerial photography

Presently every country is generally provided with the necessary means either public or private to perform aerial photography.

In 1981, aerial photography unquestionably remains before all the essential operational tool for inventory cartography. But its cost (from 4, 5 to 8 $US per sq. km.) makes aerial photography a precision instrument exclusively used to investigate phenomena developing within space limits and undergoing a slow evolution, rather than a general and systematic monitoring tool.

Anyhow, new and recent developments in aerial photography techniques have adapted it particularly well to desertification problems and made it very profitable from a cost standpoint.

Small-scale photography

Small-scale photography (1 : 60.000 to 1 : 110.000) can be considered presently and for a 10 year period at least, as one of the most operational Remote Sensing means in view of PACD implementation.

This type of photography is quite recent as it takes advantage of jet aircraft with a 35,000 feet ceiling and uses very short focal lenses (88 mm in 23 x 23 cm size) produced in the last ten years.

For the time being, and up to the advent of stereoscopic high resolution satellites, it is obviously the best adapted tool and the cheapest per surface unit for studies at a national level and the development of master plans.

It is possible, indeed, with the same financial investment and starting with general overall monitoring (1 : 500.000 and 1 : 250.000) covering, for instance, the national territory, a geographical region, intermediate administrative units (district, department, etc...), to reach the accuracy of large-scale arrangement schemes (1 : 25.000 up to 1 : 10.000).

Significance of former photographic coverages

These are usually panchromatic black and white, allowing, especially when renewed every five, seven or ten years, to make valuable comparisons providing scientists with a dynamic view of the evolution of the phenomenon in relation to time and surface. For instance, it is possible to compare the condition of natural vegetation and the limits to its extension, the distribution and types of farming, the location, size and number of built-up areas, the progress of erosion phenomena or the changes in dune systems, in salt soils and hydrographic network, etc.

Former aerial photographic coverages constitute a scientific reference document, a cartographic and statistic memory.

Airborne remote sensing

Airborne remote sensing includes the following tools:

- Thermal infrared scanners or cameras working in the thermal part of the spectrum, generally 3.5 – 5.5 and 8 – 14.

- Multispectral visible and near infrared scanners, cameras and push broom systems.
- Microwave imaging radars : side looking airborne radars band L and band X with real or synthetic antennas.
- Various instruments based on laser for topographic profiles and pollution sensing.

In the case of desertification only a few systems are relevant such as:

A. Thermography or imaging in the thermal infrared part of the spectrum. This method uses generally a scanner mono or multispectral. Pictures or data reveal the radiance temperature differences and some other thermal parameters such as emissivity.

Thermography is one of the most promising ways of remote sensing especially in the view of application to arid zones. The thermal behaviour of water in the ground and in the plants is so well defined and different from other thermal bodies or objects than it is possible to detect water existence and contents. Compared with the visible part of the spectrum including the near infrared available or false colour photography, thermography brings original and important information.

Among the applications of thermography can be quoted:

- Study and mapping of soil evapotranspiration.
- Search and mapping of humid zones at the surface or subsurface.
- Search of fresh water discharges near shorelines corresponding to continental deep tanks.
- Study of the thermal constraints of soils in view of optimization of the water expenses in irrigation projects.

At least two ESCAP countries, India and China, are equipped with thermal scanners. It must be considered, however, that the major problem of using thermography is situated at the level of interpretation which needs special capabilities, special data processing and highly specialized training.

B. The multispectral analysis and imaging in the visible uses mostly 10 to 24 bands scanners.

The huge quantity of data to be stored and processed make this tool more experimental than operational. As soon as operational work has to be done in 90 per cent of the cases, aerial photography is prefered.

C. The microwave radars. Radars are 100 per cent operational for topographic mapping in cloudy zones and to follow deforestation. But concerning the other fields of desertification studies, it can be still considered more as an experimental way. Several experiments around the world are under way to assess the accuracy in water content measurements in soils.

Remote sensing from satellite

A. Landsat first generation (ERTS 1, LANDSAT B, C)

- Ground resolution : MSS 80 meters
  RBV 30 – 40 meters
- Altitude : 920 km.
- Revisit : each 18 days
- Field of view (one scene) : 180 x 180 km.
- 4 spectral channels

Since 1972, the three Landsat satellites have imaged nearly all the surface of the emerged lands and several photos have often been made on each place of the world. But all the regions have not been imaged with the same frequency.

On an average, arid zones have not been recorded more than 4 or 5 times in the 8 years Landsat period. This revisit rate is generally sufficient on desertic areas where ecological changes are nearly non-existant but it shows itself insufficient on semi-arid zones. As a matter of fact, monitoring of seasonal and inter-annual changes provides rich information for the scientists on plant ecology and biomass measurements farming and crop, hydrology and pedology.

On the cloudy regions, it is very exceptional to get an homogeneous coverage inside of the same year, in that case, comparisons between pictures of different years are difficult. On the other hand, several photos are available during the dry season but these are generally of little interest because of the fewer changes during this period.

B. The future height resolution satellites: Landsat D and SPOT

The high resolution will open up in the near future the efficiency of remote sensing techniques : the research instrument of last 10 years will turn into a more operational system.

With regard to the nature and the quality of final information, several steps forward will be taken, all in the way of an important increase in the diversity and accuracy of the results available for scientists and planners.

Landsat D because of the 30 metres resolution of its "thematic mapper" and its 7 spectral channels is hoped to improve vegetation, land-use and agriculture mapping. Two years after, SPOT will bring more information inside of small parcels, irrigation projects, hydrographic and communication networks, habitat and population mapping. Above all its steresocopic capability will improve all geomorphological performances of remote sensing and, beyond this, the results in soil sciences.

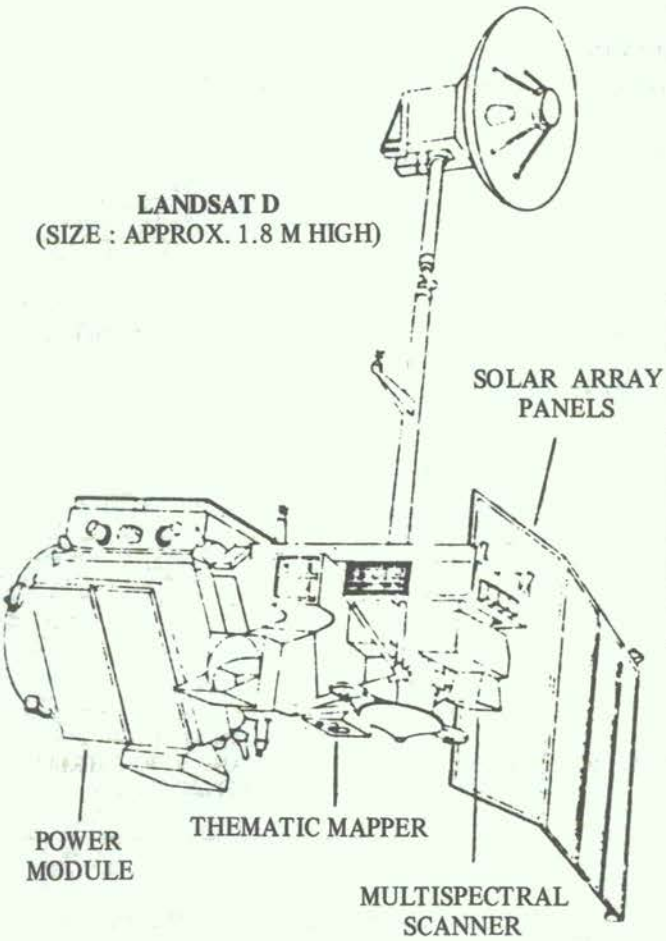
Considering the general improvement of performance as early as 1982, it is important to consider the dissemination of the data: existing Landsat receiving stations must be deeply modified to receive the Landsat D thematic mapper. Pratically a new station has to be built. On the other hand, as Landsat D and SPOT will transmit their high resolution data flow in the same frequences, a 10 to 15 per cent extra cost only will be necessary to receive SPOT with a Landsat D receiving system.

Dissemination policies of NASA and CNES are obviously different: NASA seems to give more priority to the data transfer via its new TDRSS satellite network while CNES prefers to give more independence to the countries by keeping the tried system of Landsat first generation combining national and/or regional receiving stations and one main centre (SPOT-IMAGE in Toulouse) for non-covered areas through local stations.

The 10 metres resolution of SPOT is hoped to bring new and significant information of PACD, through social and economic data related to habitat; population; livestock; localization of the urban agglomeration and villages with numbering of habitations; following up the movement of villages due to desertification progresses and studies on transhumance.

Thanks to stereoscopic capabilities combined with the 10 metres resolution, geomorphology related to soil sciences and especially studies on erosion will profit by new and precious data such as regular and frequent national balances of erosion.

LANDSAT D



SPECTRAL COVERAGE OF THEMATIC MAPPER

BAND	MICROMETERS
1	0.45 - 0.52
2	0.52 - 0.60
3	0.63 - 0.69
4	0.76 - 0.90
5	1.55 - 1.75
6	10.40 - 12.50
7	2.08 - 2.35

The next satellite planned in the Landsat series will be the Landsat D (or, after successful launch, Landsat 4). It is currently under design and fabrication by NASA and its prime contractor, General Electric. It will serve as the platform for a multispectral scanner (MSS) similar to that currently in operation aboard Landsat 3, and a new thematic mapper.

Landsat D will have a nominal orbital altitude of 705 km and a descending equatorial crossing at about 9:30 - 10:00 a.m., and it will maintain a 16-day cycle of repetitive coverage. The two onboard sensors will provide ground coverage of about 185 x 170 km per scene.

The MSS will sense data in the same 4 bands as the present MSS on Landsat 3, and will have the same instantaneous field of view (80 metres).

The thematic mapper, a line-scanning device also, will operate over 7 bands and have an instantaneous field of view of 30 metres.

A new ground processing system is being implemented at NASA/Goddard for Landsat D data. The system will receive sensor data via the new Tracking Data and Relay Satellite System (TDRSS) and will produce high-density tapes, computer-compatible tapes, and film of the data within 48 hours.

Approximately 200 MSS scenes per day will be converted to geometrically uncorrected high-density tapes in the same format as the HDT-AM of Landsat 3. These tapes will then be transmitted to EDC and will become the archival masters for product generation and dissemination. The geometrically corrected output pixel size will remain 57 metres square.

Approximately 50 scenes per day from the thematic mapper will be geometrically corrected and converted to high-density tapes. NASA/Goddard will then generate 241-mm film from these tapes and ship the film to EDC. This film will become the archival master for product generation and dissemination. The geometrically corrected output pixel size of thematic mapper data will be 28.5 metres square.

COMPARISON OF:

	LANDSAT-D TM		LANDSAT-C MSS	
	MICROMETERS	RADIOMETRIC SENSITIVITY (NE∆P)	MICROMETERS	RADIOMETRIC SENSITIVITY (NE∆P)
SPECTRAL BAND 1	0.45 - 0.52	0.8%	0.5 - 0.5	.67%
SPECTRAL BAND 2	0.52 - 0.60	0.5%	0.6 - 0.7	.67%
SPECTRAL BAND 3	0.63 - 0.60	0.5%	0.7 - 0.8	.65%
SPECTRAL BAND 4	0.76 - 0.90	0.5%	0.8 - 1.1	.70%
SPECTRAL BAND 5	1.65 - 1.75	1.0%	–	–
SPECTRAL BAND 6	2.08 - 2.35	2.3%	–	–
SPECTRAL BAND 7	10.40 - 12.50	0.5K (NE∆T)	10.40 - 12.50	1.4K (NE∆T)
GROUND IFOV		30M (BANDS 1-5) 120M (BAND 5)	79M (BANDS 1-4) 237M (BAND 5)	
DATA RATE		83 MB/S	15 MB/S	
QUANTIZATION LEVELS		256	64	
WEIGHT		163 KG	75 KG	
SIZE		1.0 x 1.0 x 1.8 M	0.35 x 0.4 x 0.9 M	
POWER		250 WATTS	42 WATTS	
ALTITUDE		715 KM	917 KM	

NE O = NOISE EQUIVALENT REFLECTANCE
NE T = NOISE EQUIVALENT TEMPERATURE

SPECTRAL BAND RATIONALE

OFFICE OF
SPACE AND TERRESTRIAL
APPLICATIONS

0.45 - 0.52 UM

- BATHYMETRY IN LESS TURBID WATERS: SOILNEGETATION DIFFERENCES; DECIDUOUS/CONIFEROUS DIFFERENTATION, SOIL TYPE DISCRIMINATION

0.52 - 0.60 UM

- INDICATOR OF GROWTH RATE AND VEGETATION VIGOR BECAUSE OF SENSITIVITY TO GREEN REFLECTANCE PEAK AT 0.55 UM, SEDIMENT CONCENTRATION ESTIMATION: BATHYMETRY IN TURBID WATERS

0.63 - 0.69 UM

- CHLOROPHYLL ABSORPTION/SPECIES DIFFERENTATION ONE OF BEST BANDS FOR CROP CLASSIFICATION, VEGETATION COVER AND DENSITY: WITH THE 0.52 - 0.60 UM BAND IT CAN BE USED FOR FERRICIRON DETECTION, ICE AND SNOW MAPPING

0.76 - 0.90 UM

- WATER BODY DELINEATION: SENSITIVE TO BIOMASS AND STRESS VARIATIONS

1.55 - 1.75 UM

- VEGETATION MOISTURE CONDITIONS AND STRESS SNOW CLOUD DIFFERENTATION; MAY AID IN DEFINING INTRUSIVE OF DIFFERENT IRON MINERAL CONTENT

2.08 - 2.35 UM

- DISTINGUISH HYDROTHERMALLY ALTERED ZONES FROM NON-ALTERED ZONES/MINERAL EXPLORATION: SOIL TYPE DISCRIMINATION

10.4 - 12.5 UM

- SURFACE TEMPERATURE MEASUREMENT. URBAN VERSUS NON-URBAN LAND USE SEPARATION; BURNED AREAS FROM WATER BODIES

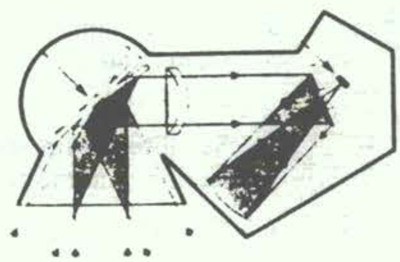
TM BAND LOCATIONS HAVE BEEN OPTIMIZED TO MISS WATER ABSORPTION BANDS.

SPOT SYSTEM

L'instrument HRV
The HVR instrument

Caractéristiques de l'instrument HRV / *Characteristics of the HVR instrument*	Mode multibande / *Multiband mode*	Mode panchromatique / *Panchromatic mode*
Bandes spectrales	0.50-0.59 µm 0.61-0.68 µm 0.79-0.89 µm	0,51-0,73 µm
Spectrum bands	*0.50-0.59 µm* *0.61-0.68 µm* *0.79-0.89 µm*	*0.51-0.73 µm*
Champ de l'instrument	4.13 degrés	4.13 degrés
Instrument field	*4.13 degrees*	*4.13 degrees*
Dimension du pixel en visée verticale	20 m × 20 m	10 m × 10 m
Pixel dimension with vertical sighting	*20 m × 20 m*	*10 m × 10 m*
Nombre de pixels sur une ligne	3 000	6 000
Number of pixels on a line	*3 000*	*6 000*
Longueur d'une ligne balayée au sol, en visée verticale	60 km	60 km
Length of a line scanned on the ground during vertical sighting	*60 km*	*60 km*
Codage du pixel	3 × 8 bits	6 bits DPCM (1)
Pixel coding	*3 × 8 bits*	*6 bits DPCM (1)*
Débit d'information	25 M bits/sec.	25 M bits/sec
Data flow rate	*25 Mbits/sec*	*25 mbits/sec*

(1) DPCM est un mode de compression de données qui permet de conserver 256 niveaux de gris.
(1) DPCM is a data compression technique which allows 256 grey levels to be stored.



The SPOT system was designed by the Centre National d'Etudes Spatiales and is produced by France in association with her European partners (Belgium and Sweden). It comprises an Earth observation satellite and ground stations to receive the data transmitted.

The first satellite, due for launch in 1984, will carry a useful load comprising two identical HVR (High Visible Resolution) instruments. These allow observations to be made with a groundlevel resolution of approximately 20 metres in three colour bands in the visible spectrum and close infra-red and panchromatic images in black and white. In this second case, the ground-resolution is approximately 10 metres. This configuration is suitable for observing the small agricultural plots found in many countries. It also satisfies normal cartographic requirements.

The instrument sighting head contains a flat mirror which can be orientated by remote control. This allows the line to be moved perpendicular to the orbit. It is possible to move the mirror 27° on either side of the vertical position, in 45 steps each of 0.6°, which allows an area of up to 475 kilometres on either side of the satellite's ground path to be traced. The maximum angle of incidence with the ground is 33° due to the curvature of the earth.

This lateral-capability will allow the satellite to observe any region of the Earth with a frequency of one to several days, which will make it possible to monitor relatively quickly developing local phenomena. It will also be possible to achieve stereoscopic images of the relief in the regions observed by associating views taken from different angles.

The SPOT satellite has a total mass of approximately 1750 kg. at the beginning of its life, and will be placed in an almost polar circular orbit at 832 km. altitude by the European Ariane launcher vehicle.

The planned life span for the first satellite is two years. A spare satellite is planned. Subsequent satellites, to ensure continuity in the data collected, are being designed.

In particular, SPOT will be used for:

- Studies on land use and the evolution of the environment;
- Evaluation of renewable natural resources (agriculture, forest.....);
- Assistance in surveying mineral resources;
- Cartographic works in the medium scale range, such as 1:100,000, and preparation of thematic maps at scales of approximately of 1:50,000 and their frequent up-dating.

Data collection systems

(a) Operating principle

Data collection systems provide a means of communicating information, including position data, from a large number of platforms distributed all over the world to one or more central stations with a very good efficiency and very low cost.

Essentially, such systems comprise:

- A large number of fixed or moving terrestrial platforms equipped with measuring instruments and a platform transmitter package that is totally independant of the satellite and the rest of the system.
- Satellites equipped for such continuous functions as platform message reception, data collection, and message retransmission to ground stations (NOAA Meteorological satellite).
- Central ground stations that receive the data transmitted by the satellite(s), sort it, then send it either directly or indirectly to a data processing centre.
- A data processing centre that receives all data forwarded via the different central stations and distributes the processed data, in usable form, to system users.

Data collection is based on the random access principle. This means that the platform transmitter packages transmit their messages periodically on the same frequency and without the need for satellite interrogation. Messages from platforms within a satellite's coverage thus appear at the input to the onboard receiver in a random fashion. Apart from actual message acquisition, the onboard also ensures the proper separation of messages from different platforms.

(b) Applications

Platform location and data collection systems make it possible to obtain measurement data from inaccessible, uninhabited and severe environment areas. The location capability also makes it possible to track moving platforms and to study the motions of the media supporting such platforms. Lastly, systems of this type, with their inherent worldwide coverage, make it possible to undertake vast study projects on a global scale.

The applications of such systems are many and various. They do, however, fall into three broad areas. The earth sciences, and in particular biology (animal tracking), hydrology and geology are using platform location and data collection systems to develop new working methods based on the possibilities offered for obtaining data from large areas and from places that had previously been inaccessible.

Other disciplines belonging to these three broad areas and directly concerned by the possibilities offered by platform location and data collection systems include : agriculture, ecology, remote sensing of earth resources, etc.

For wide areas to be monitored, DCS is surely one of the cheepest existing means and one of the easiest to manage.

(c) The Argos system

The Argos platform location and data collection system is the fruit of a co-operative project between CNES (Centre Nation d'Etudes Spatiales, France), NASA and NOAA (National Oceanic and Atmospheric Administration, USA). CNES, benefitting from the experience acquired in this type of activity through the Eole programme (1970-1974), is the prime contractor for the design, development and operation of the system.

The Argos system comprises:

- A space segment consisting of two satellites in orbit at any one time, each being equipped with an onboard data collection system ensuring platform message reception, processing and re-transmission.
- The set of all user platforms.
- The ground data processing centres.

At any given moment, each satellite "sees" all the platforms located within a circle 5,000 km. in diameter. As the satellite orbits, the ground track of this circle corresponds to a swath 5,000 km. in width encompassing the earth.

Small local DCS receiving stations can provide monitoring on a 3,000 km. diameter area. For example such a station situated in Jodhpur can monitor all the India Territory.

The overall capacity of the Argos system, while satisfying the probabilities just mentioned, is 16,000 data-collection platforms.

Assuming nominal system operation, the interval between data collection and the making available of results to system users at the Toulouse data processing centre, is less than six hours after the onboard recording of the corresponding message. Local DCS stations receive data immediately in real time.

Synthesis on monotoring tools

1981-1984 Period

Three operational tools

1. Data collecting by satellite, in particular through Argos system, allows an automatic collection of highly diversified data performed very fast and at very low cost, over areas as large as all of ESCAP countries. The data collection system enables the user to centralize immediately all information data under standardized filing arrangements, thus preventing most of the risks resulting from transportation, coding and conventional filing of widely scattered data.

Right now and without involving heavy investments, full advantage can be taken of the data collection system. Its practical utilization is most simple and the training of necessary technicians does not take much time. Only a few persons, from two to ten per country, are required to operate the equipment. Its basic cost, as well as the operational expenses, are very cheap. Lastly, it is a means fully mastered politically by all concerned countries, who are free to install or not to install the required transmission poles and stop it at will.

2. Remote sensing at the national level (for an average surface country). Small-scale aerial photography (1 : 60.000 – 1 : 100.000) can presently boast of the best quality/price ratio, allowing, thanks to high speed aircraft, the collection of homogeneous and reliable information.

It also provides a valuable gain prevailing in accuracy over cartographic compilation methods and small-scale land surveys. It can be used whatever the operation scale when making out master plans; it remains the main instrument up to an advanced detail stage of project development.

3. At the regional level or when extensive countries are involved, Landsat MSS is an excellent tool for very small-scale inventories (1 : 250.000 maximum), especially for land-use cartographies. Landsat shows especially useful when no cartography or photographic coverage is available. Landsat allows a rather steady monitoring and it can be operated fast enough to get several evaluations per year.

However, the spectrum fit for use is very narrow in consideration both of the best adapted scales and of the thematic information accuracy. Landsat R B V provides a relative reliability in localization, but rather poor information on phenomena related to desertification. By combining MSS and RBV data processing, it is possible to obtain a more efficient use of Landsat especially in the scope of agriculture. This type of processing is not yet extensively used and remains expensive. Landsat D should provide serious progress as it will make it possible to reach scale 1 : 100.000 due to an increased multispectral identification power. Anyhow the 30-metre resolution power will not yet allow current working scales at the level of master plans.

Research tools

N O A A metereological satellites series (or the geostationary satellites, if any in the region) allow, by using their channels within the thermal infrared to obtain significant information covering the radiation evaluation, the water percentage in the atmosphere and in the soils, as a complement to the information collected in the visible through remote sensing.

However, the utilization of thermal infrared by satellites is at the experimental stage, but it is most probable that we shall see in the coming years swift progress in application conducted in the fields of water and evapotranspiration of soils and vegetables.

On a larger scale, airborne thermal scanners will allow to accurately localize and to study phenomena related to water transfers in soils. For instance, remote sensing and the cartography of infero-flux running under the bottom of the large fossil valleys sweeping down from the Himalaya in north-west India should be powerfully backed up before too long by thermal observation.

From 1985 onwards

The data collection system should extend its application field thanks to new sensors and to a data collection every day more diversified.

In the scope of remote-sensing, SPOT satellite when operating, should modify the basic configuration of the previous period, SPOT being designed to replace small-scale aerial photography. But above 1 : 30.000 SPOT images will have to be completed by images providing a higher and more accurate resolution, especially in the scope of dwellings, communication networks and relief details. The basic operational configuration of an evaluation and monitoring system at a national level can, therefore, be reduced to two types of documents only: SPOT images and large-scale aerial photography (1 : 10.000 and above). In relation to some regional aspects or for identification purposes, Landsat D images could usefully complement SPOT image information.

Facilities available in the region

The data collection system, although it be operational, does not seem to have been a target for the implementation of the necessary equipment in the region. But as this implementation is easy and cheap, it should not encounter any obstacle from the moment this information task is undertaken. Conversely remote sensing has attracted significant efforts concerning equipment and training, but in most countries there still is a long way to go to make this service perfectly operational; much effort is still necessary.

It can, nevertheless, be admitted that a valuable basis is available all over the region, but the standard of such facilities differs from one country to another. This is true from the triple standpoint of equipment, users' training and the framework in which this technique is integrated.

India and Iran have installed Landsat receiving stations but the Iranian station does not seem to be operating for the time being. Most advanced projects exist in Thailand, China and Indonesia. India (NRSA) and the Philippines avail themselves of data processing systems for image processing and another complex should be set up in Bangkok at the Asian Institute of Technology in 1982. Bangladesh has just purchased a complete remote sensing centre with a Landsat D – SPOT station containing a complete data processing system (operational in 1982) and a Landsat D – SPOT receiving station.

Considering the outstanding projects and the up-dating work to be performed on existing Landsats, it is liable that the full coverage of concerned countries will be effective from 1984, except perhaps on part of the Philippines (see map).

With reference to training, the conclusions drawn up by P N U D mission in 1980, state that some countries, like the Philippines, want the training of the majority of their specialists to be achieved as in the past in foreign countries.

Generally speaking, P N U D mentioned that it was necessary to improve the training efforts displayed in the region, in particular in the scope of applications.

The action against desertification which can be considered as one of remote sensing's major application themes within ESCAP countries, will be the subject of a specific training effort. As a matter of fact, this type of work requires significant competence both in the field of desertification and in all remote sensing operational techniques, including photo interpretation at a high level. It must be figured out that at least one year is necessary in the efforts displayed to complete the training of an experienced technician in remote sensing.

Practically speaking, let us say that this type of technician does not exist and at the present time even in remote sensing there are specialists in Landsat image or in aerial photography, but very few enjoy a command of both systems.

Training and research centres such as the CAZRI and Dehra-Dun Photo Interpretation Institute in India, have at their disposal excellent facilities. So has the future AIT Regional Training Center in Remote Sensing in Bangkok. With the assistance of some expert specialists, both should contribute to work out the problem of regional specific training.

Requirements for a more thorough study

The definition of a global monitoring system of desertification will be drawn up by a group of scientists. The competence of this group should extend over monitoring tools techniques, have a global understanding of the desertification phenomenon on the regional scale, be familiar with all the problems of price and cost of the various tools available and have practical experience in the work to be performed in the region.

ESCAP having shown its competence to conduct such studies at the region level, could be considered as an excellent administrative and logistic basis for such an undertaking.

The technical team should consist at least of:

- 1 very high-level expert in desertification having a great command of all the aspects of the problem in the region.
- 1 expert in data collection systems
- 1 expert in applying remote sensing of desertification problems
- 1 ESCAP representative
- Eventually one representative of the international financial organizations (UNDP, IBRD).

Summary of conclusions and recommendations

Monitoring the desertification processes and controlling the actions undertaken to overcome it must be considered as absolutely necessary and directly complementary to all the information systems and studies to be conducted to expel desertification. They should, in concerned countries, enter the same category as the meteorological services all over the world.

Monitoring role is double. It is meant to:

(a) Enlarge our scientific and practical knowledge as required to draw up master plans, contributing accordingly to select non-degrading actions.

(b) Operate as a warning signal detecting the appearance of the desertification phenomenon in contaminated zones and the inefficacy of ill-conceived actions.

Considering the technical bases existing in the concerned countries of the region, we may deem, in 1981, that installing an operational monitoring system in a future not too remote is a realistic view of the situation.

Technically speaking, modern operating tools can be recommended as follows:

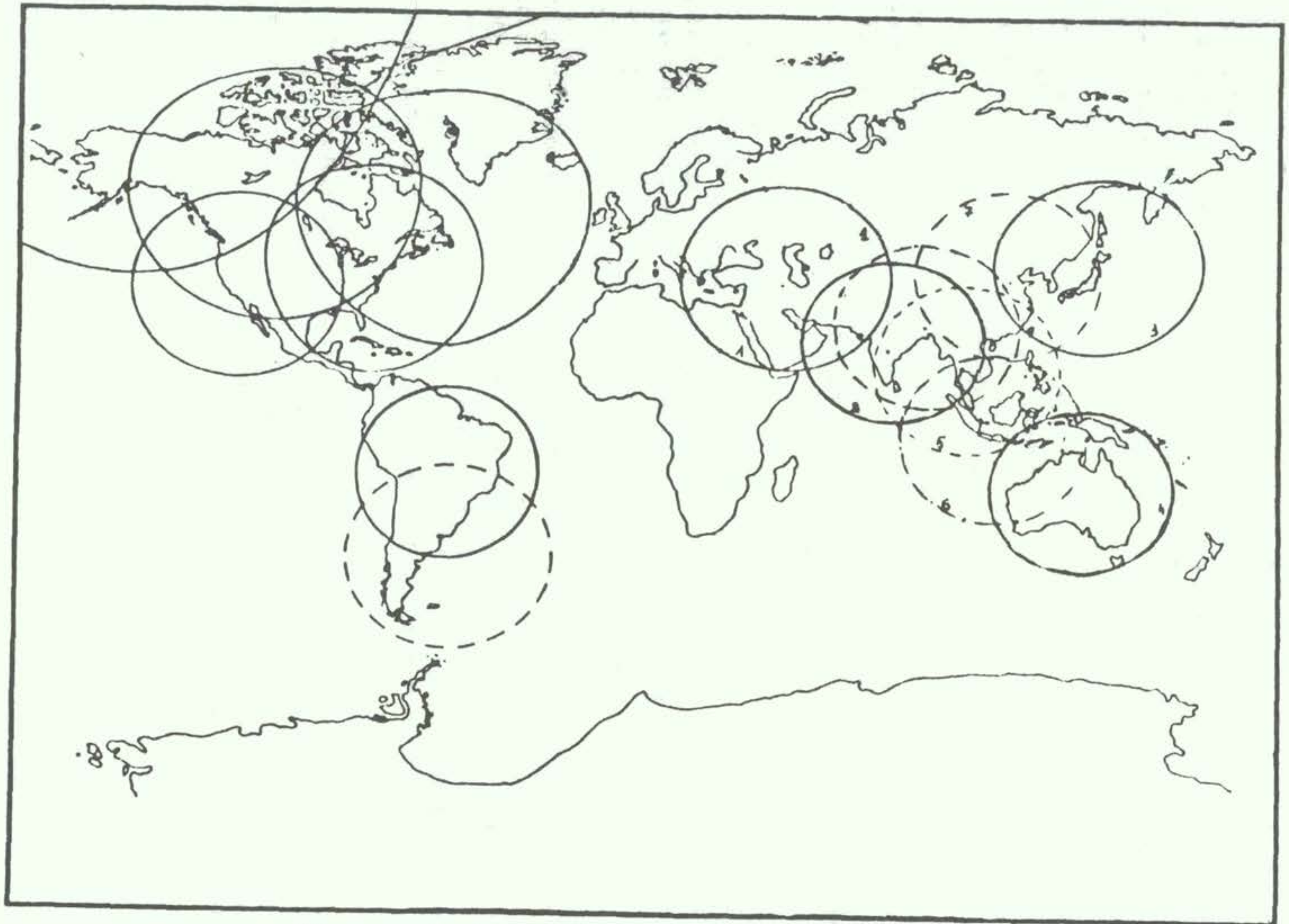
- We should immediately conduct investigating discussions and reviews on D C S at the national and regional level.
- Aerial photography on a small scale, data collection systems and Landsat images for very tiny scales.
- From 1983 onwards Landsat D followed by SPOT in 1984, and the increased capacity of sensors and of D C S network should allow to build up a complete monitoring system of desertification at a very realistic cost and contribute accordingly to intensify the necessary actions against such desertification.

An efficient monitoring system should be backed up, simultaneously and in such a way as to be complementary, national actions which will figure out the major portion of the system and by the regional organization in regard to "transnational" aspects.

Specific training of monitoring specialists should be considered and it is advisable that a regional training center be set up.

A more detailed study conducted by a group of experts is required to work out technical and financial propositions, taking into account the advice of the various concerned countries.

APPROXIMATE COVERAGE OF GROUND RECEIVING STATIONS IN ASIA



LANDSAT MSS BAND S

1. IRAN
2. INDIA
3. JAPAN
4. AUSTRALIA
5. THAILAND
6. INDONESIA
7. CHINA

Existing
Planned

LANDSAT D – SPOT

Planned : BANGLADESH (8)
Considered : INDIA
AUSTRALIA
JAPAN
INDONESIA

The approximate receiving ranges of all existing or proposed ground stations are shown here. The common reception radius is LANDSAT A, B, C, 2780 km.

LANDSAT D : 2,363 km
SPOT : 2,600 km

II. HYDRO-METEOROLOGY

Technology on Meteorological and Hydrological Aspects of the Combat Against Desertification*

A. INTRODUCTION

The concept

During the last few years numerous wide-ranging discussions have been held at international, regional and national level on the concept of desertification and many definitions of the phenomenon have been proposed. Unfortunately, general agreement has not been reached either on the inherent nature of desertification or on the fields of science and technology which should be encompassed in its study.

In this paper we shall regard desertification as the spread of desert-like conditions in arid or semi-arid areas. We shall concentrate on the meteorological and hydrological aspects of biological degradation in areas of rain-fed rangelands and cultivated crops with inadequate moisture supply and in areas of irrigated agriculture with risks of salinization and alkalinization.

The soil, the existing vegetation, the climate, the water resources and land-use together, must be taken into account in consideration of the desertification processes, their arrest or their reversibility. This paper does not use the word desertification to mean a process due only to human actions. The word is given its broader meaning of a reduction of biological productivity caused by a combination of physical, natural and anthropogenic factors.

Nor is it thought desirable to argue, as some writers have attempted to do, that the effects of temporary drought or devastation by a locust invasion, for instance, should be separated from the collective causes of desertification. Destruction of vegetation cover by a locust plague may have results very similar to those of over-grazing by man's domestic animals. On an arid rangeland, with grazing at its critical limit, a year of drought or a succession of dry years may be the starting point of long-term desertification.

In well-watered temperate regions and in the humid tropics with non-toxic soils the regeneration of vegetative cover of bare soil is automatic and rapid without any intervention by man. In fact a large proportion of farming effort is aimed at the prevention of growth of undesired species. On the other hand, whatever action man may take in major hyper-arid areas of the world, he will have no success in large-scale regeneration of vegetation under present climatic conditions. Climatic changes such as those which have certainly occurred in prehistoric ages would be necessary before man's intervention could be effective.

Between these extremes of climate and regenerative capacity of vegetation lie continuous ranges of ecological conditions in which the human race is capable, to a greater or lesser degree, of influencing biological productivity. Some lands are already subject to desertification or may become prone to degradation if the limitations of climate and soils are not respected. Throughout these ranges there is much that man can do in his use of the land to employ the beneficial aspects of climate, soil, water resources and vegetation and to mitigate the adverse effects which may lead to imbalance of ecological conditions.

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* Submitted by the World Meteorological Organization.

Since man's actions are more subject to control than climate or soil and vegetation types, there is justification for aiming primarily at improvements of land use within the limitations imposed by nature.

The processes

Desertification in unirrigated areas primarily involves a reduction of plant cover under conditions of climate, soil and treatment by animals and man which reduce growth of vegetations to a level at which regeneration is impossible or extremely slow.

According to Le Houérou (1977), where vegetation in an arid zone is not degraded, there is always a diffuse ground cover of at least 20 to 40 per cent of perennial species such as shrubs, undershrubs and perennial grasses, and under such cover wind erosion is compensated by particles deposited behind the obstacles that perennial plants constitute.

Decrease in the vegetation cover increasingly exposes bare soil to degradation of its surface, structure and constituents. The surface is exposed to high insolation, large diurnal temperature range, rapid evapotranspiration, impact of raindrops and wind. The humic content of the soil is reduced and its surface altered. In dry conditions the soil at the surface is dispersed into fine and loose particles especially on animal-trampled areas and cultivated lands. The wind completely carries away the finest particles and organic matter and grains up to two or three millimetres in diameter are moved over distances varying from several metres to many kilometres. Raindrops further disintegrate soil aggregates washing the finer particles into pores of the soil surface to create a sealed surface. On such a surface, regeneration of plant life is difficult and penetration of rain into the soil may fall as low as 20 per cent of the rain amount. Surface run-off eventually causes soil loss by water erosion on sloping surfaces.

These processes result in an arid climate at surfaces which are sealed, sandy, stony or barren rock. High day temperatures, reduced moisture, sand blasting by the wind and, above all, permanent removal of fertile soil, result in stunted growth or death of many remaining plants and make establishment of young seedlings extremely difficult.

Year-to-year climate fluctuations and the resultant water resource variations mean that biological production is far from uniform in all years. Unfortunately the arid and semi-arid regions show a remarkably high interannual variability, sometimes with runs of successive drier years such as those which occurred in the Sahel from 1968 to 1973 and from 1910 to 1915. It is precisely in periods of low plant production, when vegetation is most in need of respite to recuperate its regenerative powers, that the greater demands are made by man and his animal herds on the smaller amounts of food available.

Paradoxically, however, a series of wetter years with good grazing may lay the foundation for a high animal population which will result in over-grazing and desertification in the subsequent leaner years. Similarly, unless precautions are taken, a wetter period attracts arable farming into semi-arid regions which are quite unable to withstand the effects of cultivation even in an average year.

The average climatic or water resource year is a poor guide to wise land-use in sub-tropical semi-arid regions.

We consider that in a paper on the meteorological and hydrological aspects of the combat against desertification in the ESCAP region it is essential to include salinization and alkalinization as factors in desertification. Irrigation is already widely practised, there are possibilities for its extension and it is more obvious how man can control his interventions in such desertification processes than in degradation of vegetation on rain-fed lands.

Apart from such cases as the Great and Little Rann of Kutch at the mouth of the Indus valley, where periodic invasion of the sea causes very sparse vegetation mainly of salt-tolerant grasses, salts are applied in poor quality irrigation water. Where amounts of salty water applied at the soil surface are less than, or approximate to, the losses of water to the atmosphere in evaporation and transpiration there will be an accumulation of salts. Removal of accumulating salts beyond the root zone of plants by leaching and drainage is essential. With some types of soil, of soil profiles and of topography such removal of salts is very difficult and costly. The possibility of deterioration in water quality from return flow of drainage water downstream exists.

Meteorological and hydrological technology can greatly assist planning of projects by irrigation engineers but the difficulties of designing a permanently efficient irrigation system in some cases must be admitted. In some regions of high evaporation, irrigation water of poor quality and heavy soils the options may finally be only between ecological violations of nature and no intensive agricultural production.

Because of soil variations and slight undulations even on apparently flat land, neither rainfall nor irrigation water infiltrate completely evenly into irrigated fields. Some patchiness in results is almost inevitable.

Removal of water for irrigation from rivers and streams may cause a critical reduction for users downstream at minimum flow periods. Such reduction and the extraction of groundwater may also result in lowering of water tables, increasing aridity, the drying up of springs and marshes and the encroachment of salty water near sea coasts and salt lakes.

Reservoirs regulate the amount of water supply but they also result in changes in the sediment load, temperature and salinity of irrigation water. They may recharge nearby groundwater, raising water tables and leading to waterlogging of low-lying areas. Of course there is a kind of desertification of large areas where new reservoirs cover and destroy the original eco-system but possibilities arise of new activities such as fish farming and tourism.

Meteorological and hydrological considerations enter into many other aspects of collection and distribution of water to increase soil moisture and plant growth. On the large scale of control of flood waters and recharge of water tables hydrological information is essential and rates of application of irrigation must be decided in terms of evapotranspiration, soil moisture storage and plant requirements. Rainfall intensity is a major factor in water harvesting on the field scale by collection or spreading of water to the crop area. On micro-catchment plots small rainfall amounts are collected over a few square metres to increase water supply to individual trees or bushes.

The allogenic rivers, which carry water from higher precipitation areas through semi-arid regions, provide a means of seasonal irrigation of low-lying areas without a need for costly engineering of reservoirs and distribution systems. The ancient use of natural flooding in flood-retreat cultivations usually involves much risk of crop failure where periods and extent of flooding are widely variable from year to year. Hydrological analyses of water levels over many years is necessary to establish probabilities of dates of onset and retreat of seasonal floods and probabilities of extents of flooded areas. Only such analyses can provide information for planning of the various crop cycles which will be reliable in a sufficient proportion of years. Such analyses and methods of prediction of floods, as applied by Davy, Mattei and Solomon (1976) to desertification-prone areas of sub-tropical West Africa, show how strongly flows may reflect the high variability of summer rainfall. Flows from high mountain ranges with winter rainfall, as in considerable parts of Asia, show a greater regularity in seasonal rhythms which should permit sound planning of more reliable practices in flood-retreat cultivation systems and more advanced irrigation schemes.

Supplementary irrigation, in which crops are mainly rain-fed but irrigated only in scattered periods of moisture stress, is well worth consideration in regions in which temporary dry periods are a feature of the crop season or in which moisture supply is unreliable near the beginning and end of crop growth. The cost of applying 20 mm of water is relatively high but yields can be enormously increased with a few water applications of this order and the risk of harmful effects from such occasional irrigations is minimal.

To end this section reference is made to the fact that irrigation and other anti-desertification measures are aimed at modifications of the eco-system resulting in improved plant development.

These modifications will, in turn, change the hydrological and meteorological characteristics, in particular the runoff-precipitation relationship and the climate near the ground. Increases in vegetation development cause higher evapotranspiration, increased infiltration of rainfall, slower runoff and less sediment. Vegetation reduces the reflection of radiant energy from the sun, reduces the daily amplitude of soil surface temperature, increases atmospheric humidity near the ground and reduces surface wind speed. The influences of large irrigation areas on local rainfall may be questionable but there is no doubt that large areas of water and irrigated land appreciably modify the climate downwind. The lowering of day temperatures and raising of air humidities on the leeward side of such areas of high evaporation may be sufficient to pass thresholds which are critical in plant disease and pest development.

B. THE PROBLEMS

Distribution in time and space

There is little doubt that in geological and historical evidence there is proof of appreciable movements and changes in extent of arid and humid zones. The most recent glacial phase, ending only some 10,000 to 11,000 years ago, saw the extension of glaciation in Asia, South America, Australasia and Africa as well as over Europe and North America. There is evidence that semi-arid areas of subtropical Africa and Western Asia were wetter than we know them. The Sahara covered a considerably narrower latitudinal zone, the levels of lakes were higher and non-saline groundwater accumulated.

On the other hand, some ancient deserts are now overlain with relatively fertile soil and vegetation and other known changes in the margins of shifting dunes in Asia, Africa and Australia show that in some regions the present climate is not the most arid that has existed.

There is every reason to believe that fluctuations of climate and the well-known cycles of wild animal populations and plant production existed in prehistoric ecological systems. The influence of increasing human populations on natural processes and harmful effects of the stresses created by advancing agricultural technology are the factors which are new and most deserving of our attention.

Desertification, as we know it in the shorter term, is also discontinuous in space as well as time. Deserts do not spread along a continuous front line at a steady speed each year. Desertification occurs first in drought years in patches of specific soil and vegetation types where a fragile balance of ecological factors is at least temporarily disturbed. Over-grazing, cultivation or other mis-management aggravate the imbalance, rendering natural recovery more difficult or impossible. Where recovery of productivity is not rapid the degraded patches adversely influence adjacent areas in that they lead to changes in the local climate as well as to increased grazing and cultivation pressures on the originally more productive areas. Isolated small localities, therefore, tend to join up into larger desertified areas. areas.

On the larger scale, a feed-back process along the desert margins has been suggested. Charney (1975) and others have expressed the view that increased albedo, or reflection back of solar radiation, influences the overall dynamics of the climate over desertified areas and could result in reductions of cloud and rain. It has also been suggested by Schnell and Vali (1976) that organic nuclei are highly effective seeding agents in cunuliform clouds on which rainfall in semi-arid areas largely depends. Decrease of vegetation would result in a poorer local source of organic nuclei and less rainfall. We need not enter here into detailed consideration of such feed-back mechanisms but should note these further possible reasons why the combat against desertification should not be delayed.

On the large scale, arid and semi-arid regions of the sub-tropics are found in all continents. Whilst vast areas of northern and southern Africa and the Arabian Peninsula are water deficient, the arid parts of sub-tropical and tropical Asia, like those of North and Central America, are mainly confined to the western quarter.

In all continents the semi-arid and arid regions show marked differences in seasonal rainfall distributions according to latitude and topography. On the world scale, Mediterranean types of climate with winter rainfall and arid summers are concentrated on the poleward fringe of the sub-tropics. Regions with summer rainfall and dry cooler seasons are mostly found in the half of the sub-tropics near to the equator and the central and eastern parts of vast continents. Between these zones with one rainy season lie other semi-arid areas with two dry seasons separated by two relatively rainy periods. These are of two main types of which the first lies between the zones of Mediterranean climate with winter rainfall and those of summer rainfall. The second type is mostly between the tropics of Cancer and Capricorn over which the rain-bearing intertropical convergence zone passess twice each year following the annual march of the sun.

In the arid and semi-arid areas of the western part of the ESCAP region all these patterns of seasonal rainfall exist. The basic principles of the use of meteorology in desertification control apply generally over all the seasonal patterns, but the application of the principles must differ according to the needs in diverse land-use systems necessitated by different temperature and moisture regimes. Vegetation cover of the soil may be poorest either in the hot arid summers or in the cooler, windier winters.

Climatic trends and climate modification

The whole approach to the combat against desertification would be conditioned by our views on whether or not there is now a large-scale and long-term trend in climate and water resources and whether or not there are good prospects of large-scale modifications of climate by precipitation enhancement, diversion of ocean currents or other means.

If there is currently a long-term and continuous trend towards increasing aridity of climates in semi-arid and arid regions as a whole then we are unlikely to halt continued desertification whilst maintaining present expectations of land-use and production. We would have to concentrate on high production without degradation in regions wih less marginal eco-systems. If there is, on the other hand, expectation of a natural trend towards less arid conditions, desertification could decrease without corrective measures which would only hasten its disappearance. If we could modify climates by changing precipitation or temperature regimes we should concentrate effort on projects towards this end rather than assume that the combat against desertification will be in climatic conditions as we currently know them.

Unfortunately, no firm guidance is available. Historic records and prehistoric indications of climate changes reveal prolonged drier and wetter periods of far greater significance than anything we see today. Full explanation of these major changes is not yet available and there is no general agreement that we can do much more than assume a continuation of present climate patterns except in so far as man himself may inadvertently cause modifications. On the shorter time scale, cycles of climate variations have been found but these have insufficient rhythm, regularity or magnitude to permit their use for prediction of significant events either for the following few years or a human lifetime.

Nor do possible climate modification projects on a large scale show great promise of practical application to humidification of arid climates. Cloud seeding, increasing of heat absorption by darkening of soil surfaces, deflection of ocean currents, creation of large lakes to increase atmospheric moisture, prevention of evaporation from water reservoirs have been much discussed in scientific literature and tried in practice. The world remains unconvinced that control of climates is yet in sight and many would doubt the wisdom of attempting projects of which the total results might finally be harmful.

Research and practical experiments into possibilities of long-term predictions and large-scale modifications will no doubt continue but we must not wait for a technological break-through in these fields. Accepting that there will continue to be overall shortage of moisture in some regions and serious fluctuations of water supply in future years, there is much that can be done. In application of known technology in agriculture, ecology, meteorology and hydrology, we already have the power to control and employ more efficiently the meagre supply of soil moisture which is available for plant growth and preservation of the environment. The differences between vegetation and soil surfaces on either side of fence lines separating lands under different management which are so commonly seen in data from space vehicles and aircraft, leave no doubt that this power exists.

In the belief that there is a willingness to use this power, we should look more closely at the meteorological and hydrological principles which must be a large part of the basis for the combat against desertification.

This paper, therefore, now shifts attention to the local, even micro-meteorological, scale of plant/soil/water/climate relationships which are the background against which arable agriculture and forest and rangeland management must be practised. Not only is maintenance of vegetation the key to control of initial desertification processes, but also the improvement of biological productivity in more favoured parts of each country will reduce the human pressures on drier areas which are at greatest risk.

C. CLIMATIC ELEMENTS AND THEIR EFFECTS IN AGRICULTURE

The effects of climate in agriculture may be roughly divided into two groups – purely physical effects and physiological effects. There are, however, some harmful effects of extreme temperature damage and dessication in which physics and biochemistry are both probably involved and the combination of processes is still poorly understood.

Physical effects

First consider the direct physical effects which are relatively simple and for which the agriculturist certainly has options for remedial action. Wind is directly harmful to crops in that excessive speeds cause lodging, break the above-ground parts of plants and may completely up-root both large trees and smaller herbaceous plants. Such damage, like salt-spray damage on coasts, may be reduced by shelterbelts and wind-breaks. In the ESCAP region wind damage also occurs over large desertified areas when strong winds lift sand particles and carry them rapidly along the surface. This causes a sand-blasting of low plants which shreds leaves and reduces flowers and fruits to an unproductive state and sometimes completely buries small plants below a sand deposit. Wind-breaks, maintenance of a complete vegetation cover and avoidance of loose dry soil surfaces are obvious partial remedies for sand-blasting.

The part played by wind in pollination, the distribution of seeds, and in the spread of diseases and of pests such as locusts, should not be overlooked. Like wind erosion, the removal and transport of soil during intense rainfall and surface run-off are reduced by vegetation cover, mulching and the avoidance of loose sloping surfaces.

Snow cover, also encouraged by a mulch and by vegetation, provides useful protection against freezing winds for cereals and other low growing plants by maintaining temperature at the soil surface.

Wind, solar radiation, temperature and atmospheric vapour pressure all have direct physical effects on the evaporative demand of the air which will be discussed later in connexion with water balances and physiological requirements for moisture.

Physiological effects

Given that soil nutrients, oxygen and carbon dioxide are universal requirements of crops, it is generally true that plant growth is mostly controlled by energy and moisture supply. Plant growth takes place only within limited temperature ranges and the reproductive stages of some plant cycles are fully determined by day-length. Moisture supply limitations determine water absorption by roots and the evaporative demand of the atmosphere determines water losses through transpiration as well as evaporation.

One finds plants growing over most of the globe but the range of suitable climatic conditions for each species, or even variety, is often narrow. Some cacti require the great heat and aridity of tropical deserts whilst some aquatic plants require total submersion in cold waters of the sub-polar regions. Agroclimatology is therefore largely concerned with the determination of the climatic requirements of different agricultural crops and their diseases and pests. The work of agroclimatologists and agronomists includes matching or modifying the climate to the crop's requirement whilst the plant breeder modifies the crop variety to suit the climate and every agriculturist continuously improves total agricultural resources and productivity by improvements of technology, husbandry and management, within the limits of climatic and genetic constraints. The spread of wheat and potatoes over all latitudes from the equator almost to the arctic circle and the extension in recent years of maize into northern Europe and of tropical fruits into the Mediterranean are examples of what can be done by multidisciplinary efforts.

In the following sub-sections we shall briefly review the most important climatic elements which should be taken into consideration.

Climatic elements of importance to agriculture

(a) Net radiation

Net radiation (Rn) is the difference between all incoming and all outgoing radiation. Rn can be measured or calculated from solar radiation or duration of sunshine or degree of cloud cover and humidity data. Since heat and light energy for plants and cold-blooded animals mostly comes from this source it is measured regularly at a few special radiation observation stations. Such measurement is relatively difficult and a denser network of stations recording only the duration of sunshine is established to supplement data from radiation stations. Duration and intensity of light and of heat radiation are important in all growth processes, particularly photosynthesis. They control the reproductive phases of many plants and animals. They affect the opening of stomates and influence the rate of transpiration of plants.

Radiation, which largely controls air soil and plant temperatures, may be excessive in summer but insufficient, in the higher latitudes of parts of the ESCAP region, to meet full crop requirements in winter.

(b) Temperatures

The wide ranges of air and soil temperatures which occur in the ESCAP region require that they should be taken into account in agro-meteorological investigations. In some areas the low temperatures of winter months are a limiting factor for growth. These low winter temperatures, with hot and dry summers, leave only a short growth period for unirrigated crops which is a feature of agroclimatology in such areas. In mid-summer air and soil temperatures may be so high as to damage the properties of protoplasm which is the basis of all life in plants and animals.

(i) Air temperatures

Air temperatures are measured at a height of 1.5 to 2.0 m. above the ground in a well ventilated screen protecting the thermometers from direct sunlight and precipitation and reducing radiant energy to a minimum.

For many agricultural purposes observations of daily maximum and minimum temperatures are adequate but sufficient hourly observations and thermograms are necessary to establish diurnal variation and to provide data for special purposes. Such temperature data may help in assessment of available heat energy when no direct measurements of radiation are available.

Since the evaporative demand of the air is a function of temperature, these data and observations of a wet bulb thermometer are necessary for calculation of water losses to the atmosphere through transpiration and evaporation.

So-called grass minimum temperatures are observed at 2 to 3 cm. above open ground level. On nights of little wind and clear skies grass minimum temperatures can be several degrees below screen temperatures. Such minima are particularly important to biological activities near ground level and, in particular, studies of ground frost at this level are as necessary, if not more so, than air frosts at screen level.

(ii) Soil temperatures

At a few stations soil temperatures should be monitored to complete the picture in energy and water balance studies. Since changeable temperatures in the shallow layers of the soil can have marked effects on all biological activity, including that of organic contents of the soil, particular attention needs to be given to observations at levels just below the soil surface where afternoon temperatures may exceed 60° C.

(c) Air humidity

Transport of water from the soil into the roots and through the plant to be lost into the atmosphere by transpiration is one of the most vital biological processes. The rate of this transport, and of direct evaporation of water from the soil is a function of the water vapour deficity of the atmostphere. In hot dry atmospheric conditions it is not unusual to see plants wilting because water losses by transpiration exceed absorption by the roots, sometimes even when water is fully available in the soil.

Humidity of the air is usually measured at thermometer screen level for agrometeorological purposes and is observed at fixed representative hours. The large diurnal variation of the evaporative demand requires analysis of changes during the 24 hours.

(d) Wind

Mention has already been made of the important physical damage which can be caused by strong gales. Wind also plays a continuous and considerable part in evapotranspiration in that it removes humid air layers at plant surfaces, around animals and near the ground causing continuous replacement by drier air. In the calculation of potential evapotranspiration in the ESCAP region it will be found that in some months and areas the magnitude of the aerodynamic term is of the same order as the radiation term.

(e) Precipitation

Where irrigation is impossible the semi-arid and arid sub-tropics are totally dependent on limited precipitation and dew for plant growth. A dense network of ordinary rainfall stations is, therefore, essential to apply technology to desertification control. These need to be supplemented by recording rain gauges to determine rainfall distribution in time and for analyses of short-period rainfall intensities which are important in hydrology and soil erosion studies.

For irrigated areas the precipitation of catchment areas controls the water resources available and determines flows which must be taken into consideration for reservoir construction, system design and irrigation practice.

(f) Evapotranspiration

(i) Thornthwaite (1948), Penman (1948), Blaney-Criddle (1950) and others have developed methods for calculating potential evapotranspiration (ETP) from data mainly obtained from standard climatological stations. The Penman method involves wind speed and vapour pressure, as well as temperature, sunshine duration and net radiation, and is regarded as having the best physical basis. It has also been shown to give reasonable results in most parts of the world.

ETP is defined as "the rate of evaporation and transpiration that takes place from an extended surface of a short green crop, actively growing, completely shading the ground, of minimum height and not short of water".

(ii) The reference crop evapotranspiration (ETo) is a modified evaluation of the effect of climate on crop water requirements which has been thoroughly discussed by Doorenbos and Pruitt (1977). It is defined as "the rate of evapotranspiration from an extensive surface of 8 to 15 cm. tall green grass of uniform height, actively growing, completely shading the ground and not short of water."

Crops of different types and stages and in different climatic conditions show quite widely varying water requirements and the same authors have provided a wide range of values of crop co-efficients (kc) which relate ETo to specific crop evapotranspiration (ET crop):

$$ET\ crop = kc.\ ETo$$

For most field crops kc is about 0.4 at germination and up to 10 per cent vegetation ground cover. It then increases rapidly with ground cover during crop development to a value about 1.1 in mid-season with ground cover over 80 per cent. After full development of the crop kc decreases again rapidly to about 0.4 during drying off for harvest.

Readers are advised to refer to the work of Doorenbos and Pruitt for detailed information. In particular it should be noted for pastures that kc values largely reflect biological activity and ground cover by the vegetation so that the changes of kc for pastures depend upon grazing and hay-cutting practices as well as on the annual crop growth cycle and climatic elements.

(g) Water levels and discharges

Direct measurements are the most accurate means of obtaining information on water levels and flows of rivers and levels and yields of reservoirs, lakes and groundwater tables. All of these are indicators not only of water resources available for irrigation but also of the effects of desertification and agricultural practices on runoff and water losses by evaporation, leakage and extraction.

Levels are measured at fixed times daily and by autographic instruments. Interpolation between measured levels at river gauging stations is possible provided that the hydraulic characteristics of the river do not change very much and that there are no dams, marked narrows or other obstructions between two interpolation stations.

(h) Sediment and water quality

Periodical direct measurements of water quality are necessary in the combat against desertification. On the one hand, amount and nature of suspended particles may determine the efficiency and useful life of reservoirs and irrigation systems and chemical characteristics of irrigation water may be determinant in plant growth and salinization of soils. On the other hand, changes in vegetation and soil resulting from agricultural practice and desertification are reflected in sediment and salt quantity and quality as well as runoff patterns.

(j) Water balance

Agroclimatology makes wide use of a term of water balance in its simplest form, mostly ignoring surface run-off and drainage. This water balance is expressed, for rainfall agriculture, as precipitation (P) minus reference crop evapotranspiration (ETo) but it necessarily also takes into account the water holding capacity of soils..

Extensive examples of calculations and use of such simple water balances in agrometeorological studies for the Sudano-Sahelian zone of West Africa are given by Davy et al (1976). The calculations show, for instance, that even in the 600 mm rainfall zone of Niger the water balance is positive only in the three decades of August in 50 per cent of all years and that in 20 per cent of all cases for any ten-day period of the year the balance is negative. Used in conjunction with temperature data, such calculations give immediate indications of the probability of plant growth under rain-fed conditions and also have obvious applications in determining irrigation planning and practice.

It is important to note that although annual rainfall totals in the semi-arid sub-tropical zones of all continents are of the same order the differences in seasonal distribution of precipitation, evapotranspiration and temperature demand that water balance must be considered on a short time-scale of a week, ten days or a fortnight. Annual values and parameters such as P divided by ETP provide useful indices for simple classification of aridity but are insufficient for most practical considerations. Let us consider the very different water resources and potentials for plant growth at Hyderabad and Quetta which lie on nearly the same longitude and are only 5° latitude apart.

At Hyderabad the average rainfall exceeds 10 mm only in July, August and September and the last of these three months has only 16 mm while July has 75 mm. Temperatures during this summer rainfall are above 30° C. Both rainfall and evapotranspiration are high. At Quetta there is a Mediterranean climate with rainfall mostly below 10 mm per month from May to November but temperatures rising about 20° C in summer giving a serious water-balance deficit when temperatures are most favourable for growth. In January and February rainfall is around 50 mm but whilst the water balance is positive, radiant energy and temperatures near 5° C are too low for plant growth. The positive water balances are stored in the soil and reservoirs until rising spring temperatures permit rapid crop development.

In the combat against desertification tactics will differ considerably in the summer and the winter rainfall areas. The incomplete and brief comparison and contrast in the table below indicate some of the points for consideration with cultivated and rangeland crops.

Some Major Considerations in Conservation of Resources

	Summer Rainfall Regions	**Winter Rainfall Regions**
Water resources	Water collected when ETP is high and growth rapid.	Water collected when ETP is low and growth slow.
Cultivations	Mostly spring at beginning of rains, or late autumn.	Mostly summer or autumn.
Sowing and germination	Early summer, moisture limitations decreasing, no temperature limitations.	Late autumn, moisture limitations decreasing but low temperature limitations increasing.
Application of fertilizers	Spring. Increasing heavy rains cause leaching.	Spring. Rains decreasing and little leaching.
Main growth	Summer. Rainfall increasing but dry intervals very harmful at all stages. Higher temperature limitations increasing.	Spring. Available soil moisture and supplementary rainfall fairly regular but both decreasing rapidly.
Flowering and grain development	Last summer. High temperature and dry atmosphere limitations. Soil moisture limitations increasing for late crops.	Late spring and early summer. High temperature and dry atmosphere and soil moisture limitations increasing rapidly.
Harvest	Late autumn. Early crops liable to rain damage.	Early summer. Rain damage becoming negligible.
Grazing, vegetation cover and organic matter of soil	Vegetation increasing with rain, soil covered except in spring but rainfall very intense.	Vegetation decreasing as aridity and temperature increase. Soil exposed for long periods including any heavy winter rains.

The applications of water balance calculations in determing irrigation planning and practice are obvious and will be discussed further in the section E.

For most purposes, in studies of suitability of climatic zones for specific crops or of proneness of areas to desertification or for assessment of irrigation requirements and of crop/yield relationships, it is neither possible nor necessary to obtain water-balance values with great precision. Space, time and crop variations are all too large to permit great precision. Calculated water balances are much more easily obtained over large areas than actual measurements of soil moisture and are therefore frequently used for practical purposes.

(k) Remote-sensing agrometeorology and hydrology

Aircraft and balloons have long been used on a limited scale for over 50 years in monitoring of environmental conditions. They still have a part to play but their use is costly. During the last 20 years there has been spectacular development of the use of space satellites for remote sensing of large areas at regular and fairly frequent intervals. We shall not discuss satellite data in any detail in view of the present state of technology which involves much promise and some contentious claims. Sufficient to emphasize here that satellite observations of state of vegetation cover, of radiation balance and precipitation areas are likely to prove a most useful tool for monitoring and assessing vast areas of semi-arid grazing lands over which traditional observations at ground level are often quite inadequate. Widely accepted methodology for assessment of the extent and state of flooded areas from satellite data already exists and will be increasingly used.

(1) Micrometeorology

The normal meteorological observations made under internationally standardized conditions for macro- and meso-scale investigations cannot always provide the data required for understanding of weather-sensitive processes in agriculture. For special purposes, mainly associated with research, it is necessary to study the micro-scale interactions between the atmosphere, soil and plants. Such investigations necessitate the establishment of a few micrometeorological stations, usually at agricultural research institutes. Special meteorological instruments are exposed at or near ground level, often among growing plants, to determine the interchange of energy, water and the atmosphere in relation to both physical and biological processes.

Such stations appear to be particularly necessary for better understanding of the early processes of degradation of vegetation which lead to desertification.

D. ANALYSIS OF DATA

Period

Meteorological and hydrological observations are usually made at fixed-times, once or more daily, or as continuous records on autographic instruments. The voluminous original data thus obtained must, most often, be reduced to parameters and time units which are suitable for study of the relationships between desertification, meteorology and by hydrology. The purpose here is to discuss the basic period which is meaningful in most agricultural and desertification processes involving shorter-term plant growth, soil moisture and water supplies. Of course several other time units are occasionally necessary, for example, in consideration of shorter period wind speeds affecting plant damage or transport of sand or of intense rainfall causing water erosion or flash floods. Annual values are sometimes useful as rough indicators.

Most commonly one finds means and totals for monthly periods which are inadequate in most investigations and monitoring of biological activity and water supply. In the semi-arid regions the active growth period may cover only two or three months but is composed of many more significant periods shorter than a month, especially in summer rainfall areas.

It has become increasingly common in recent years to use the ten-day period (decade) for agroclimatic parameters. Five-day (pentade) and weekly and fortnightly values are also used. The pentade is rather shorter than necessary for many investigations. The weekly and fortnightly periods have the distinct advantage of always ending on the same day of the working week and permit easy scheduling for the routine issue of timely reports and bulletins. However, weeks are not easy to convert to calendar months. Decade values are more readily converted to monthly and quarterly parameters by modification of the last decade of each month of 8, 9 or 11 days as necessary for months not containing 30 days. For this reason the modified decade, three to each month, is usually adopted in countries where past practice of weekly or fortnightly periods has not already been well-established.

Statistics

Because of the variability of weather from year-to-year, the mean or average value over a number of days is often quite unrepresentative of conditions in which plants have grown or animals lived in a particular year. Mean temperatures or mean rainfalls for a particular time unit when averaged over several years are nothing more than a first rough indication of a climate. Minimum temperature may give no indication of the number of occasions of destructive frosts. Mean rainfall for monthly or decade periods, especially in semi-arid regions, does not even approximately indicate the value which may be exceeded on 50 per cent of occasions. The median value does so, by definition. The rainfall records for Jodhpur for the thirty years 1931 to 1960 give an average rainfall of 7 mm for the month of October. Closer examination shows approximately 50 per cent probability that in October no rain will fall, that 80 per cent of Octobers have less than the simple average but as much as 87 mm has been recorded in that month.

An examination of rainfall for 10-day or weekly periods would show much more striking evidence that the mean value is quite unreliable for planning and practice of agriculture. Thresholds and climatic ranges of significance to agriculture need to be established and frequency distributions determined for each of the climatic elements mentioned in section C.

As examples of thresholds of rainfall one may mention the assessment by Perrin de Brichambaut and Wallèn (1963) that in the Near East 25 mm of rainfall was a minimum monthly requirement for growth of winter cereals. For sowing of crops in the Sudano-Sahelian zone Cochemé and Franquin (1976) required precipitation equal to or exceeding half of potential evapotranspiration whilst Davy et al (1976) assessed that rainfall in 10 days should exceed 20 mm. From such climatic thresholds the authors mentioned above calculated the beginning of active growth periods.

For temperatures and winter cereals in the Near East, Perrin de Brichambaut and Wallèn (1963) selected the thresholds +3° and +7° C for mean minimum temperature to define the period of slow growth and to distinguish between climates with mild and relatively warm winters. For the Sudano-Sahelian zone the number of occasions in which maximum day temperatures exceeded 35°, 40° and 45° C were determined.

For cultivated crops it is usually accepted that agroclimatic and water conditions need to be satisfactory at least eight years out of ten to permit viable agriculture. For the combat against desertification more importance has to be attached to extreme conditions which even once in 30 years may trigger off a desertification process which it is difficult or impossible to reverse. This remark also applies as much to hydrological information as it does to climatological data.

Agroclimatic zoning

Thornthwaite (1948) and others have developed systems of climate classification which have been applied throughout the world with variable degrees of success. To a certain extent such macroscale classifications are useful in giving a first indication of comparability of climatic zones in different continents and countries. Division of each country on the mesoscale into relatively homogeneous agroclimatic zones for agricultural planning and practice is, however, usually essential.

With the wide range of conditions found in the ESCAP region it is impossible here to discuss in any detail the climatic elements on which such division of individual countries should be based. Each problem may need its own set of parameters. For example, the determination of zones with potentials for introduction of a new plant species requires first a knowledge of requirements of the plant in terms of climate and soil moisture and type. The tree Acacia albida, which has so many desirable qualities in the combat against desertification, requires not only tropical climate with minimum summer rainfall 400 mm but also a groundwater table accessible to the tree's roots in the dry season. The fixing of climatic limits to the spread of rain-fed cultivation, especially mechanized cultivation, requires consideration of soil types as well as amount and seasonal distribution of rainfall. Mobile pastoralists often depend upon the proximity of complementary climates to provide year-round grazing supplies.

In each country agriculturists, climatologists, hydrologists and pedologists will need to collaborate in identification of the parameters to be used in agricultural zoning.

The following major steps are common to any agroclimatic zoning: –

(i) From current knowledge identify the climatic and hydrologic constraints which are most likely to be involved in the agricultural or rangeland activity under consideration.

(ii) Collect appropriate climatic, hydrologic and crop data and analyse to find and quantify any correlations between the constraints and the crop results.

(iii) Determine significant thresholds and ranges of parameters for the constraints.

(iv) Map the thresholds and ranges.

Semi-arid and arid regions, widely used as rangelands and most in danger of desertification, have been relatively neglected in comparison with more easily accessible and more profitable arable lands for which land-use zonation studies are usually carried out. The ecological balance of rangelands is more fragile, the processes are often less well understood and less data are available. In the subtropical semi-arid regions closer attention than in the past needs to be given to measurements of crop yield and of changes in vegetation and water resource characteristics. We must determine correlations which need less frequent consideration in temperate and well-watered regions, such as correlation of wind speed and rain intensity with vegetation density and quantities of soil removed by erosion or correlation of rates of salinization with parameters of rates of irrigation and evapotranspiration.

When results of investigations in other parts of the world on a particular problem are available and when agricultural data are inadequate for the country to be zoned, there is a temptation, even a necessity, to omit steps (i), (ii) and also (iii) above. Much caution should be exercised in such cases. The characteristics of climate, soil, plant and animal varieties and agricultural management and of practices are rarely the same for two countries widely separated geographically. Even small differences in these agricultural resources may make it impossible to transfer methodology in agroclimatic zoning without due consideration to the need for local modification.

Basic data

In this paper there is no need to describe in detail all the various types of data required for agroclimatological work. Meteorological observations and networks of observing stations are well described in the official WMO publications of technical regulations and guides to practices. Experience, however, shows that practices in collection, summarization and publication of agricultural data are of very different standards in different countries. Understandably, reliable production data are much more difficult to collect in the case of products for local consumption than in the case of commercial products centrally collected for export or processing.

Data on rangeland production are particularly difficult to acquire for the further reasons that the source of production is less well defined and animal products from nomadic pastoralism are rarely marketed regularly and in identifiable relation to periods of vegetation growth. Rangeland production usually requires direct survey and measurement of vegetation on sample sites at which representative meteorological observations are also made.

Nevertheless, it should be fully realized that the relationships between climate and production can only be analysed and understood if agricultural statistics are made available. Moreover, it is necessary to identify areas cultivated, production for reasonably homogeneous agroclimatic regions and to provide separate production-data for rainfed crops, for irrigated crops and for different species and varieties of crops.

E. DEGRADATION AND LOSS OF RESOURCES

As stated in the introduction, this paper is mainly concerned with agroclimatological aspects of successful plant growth which, in turn, conserves or improves agricultural resources. Moreover, in so far as the semi-arid lands are concerned, the world is increasingly aware that increasing human pressures represent a major factor in desertification. More intensive use of agricultural resources in more climatically suitable and better-watered regions will help to relieve the human pressures on regions with delicately balanced ecological systems.

However, there is no doubt that man will continue to make use of the potential production of regions which are prone to desertification. In doing so he must continuously bear in mind the essential principles of the relationships between degradation of the environment and climate and water resources. This section briefly summarizes these relationships.

Irrigation, salinization and waterlogging

The discussion of simple water balances in section C has obvious applications in efficient planning and operation of irrigation systems. Calculated water balances obtained from precipitation and crop evapotranspiration immediately indicate the amount of water required in irrigation to meet full water requirements after taking into account the particular crop and crop stage.

Whilst irrigation water would be wasted in excessive applications it is known that many crops produce quite satisfactory yields when available water is rather less than the full theoretical water requirements.

On the other hand irrigation water with high salt content will lead to accumulation of salt when water amounts applied are less than or equal to amounts lost through evapotranspiration. Such accumulation finally leads to salinization of the soil to such an extent that crops will become unproductive unless measures are taken to leach the salts out of the soil within the penetration zone of root systems. Additional water, over and above crop water requirements, must be applied to wash away salts. The same applies to any toxic subjects applied to the soil. Excess water, whether of good or bad quality, leads to waterlogging of soils if drainage is inadequate.

Irrigation, badly practiced, is likely to lead to degradation of the soil resource. The plant resource of the original vegetation of pastures is considerably modified by irrigation and, of course, completely changed by irrigation with arable cultivation. The climatic resource is changed only slightly although effects of large irrigated areas through lowering of air temperatures and increasing of humidity may be appreciable in agroclimatic considerations. Water resources are modified in that water tables are altered by both extractions and applications of water while flows downstream may be changed both in quantity and quality.

Desertification in semi-arid rainfed areas.

To an agrometeorologist the thinning of the vegetation cover of the soil, from whatever cause, is an essential first step in desertification processes. Removal of trees, shrubs and ground cover by wood gathering, fire, land clearance or over-grazing of animals always has effects on the local climate and especially on the microclimate near the soil.

Surface wind is increased and the daily amplitude between maximum and minimum temperatures of the air and soil is enlarged. Soil denuded of vegetation is directly exposed to solar radiation and the reflectivity of the surface is increased. Precipitation effectiveness is decreased by surface runoff and decreased water-holding capacity of the soil. Water balances in summer rainfall areas are seriously reduced during plant growth periods. River flows are increased but less regular. Soil fertility declines because of reduction in organic matter, deterioration of soil structure, sealing of the surface and movements of surface particles.

Erosion

Irretrievable losses of soil occur through both wind and water erosion at rates governed by wind speed to the power 3 (V^3), by intensity and duration of rainfall and by the structure and moistness of the surface of the soil.

Preventative and remedial action

A description of the many agricultural practices involved in the combat against desertification is neither necessary nor possible here. We shall identify four main objectives in attempts to use agrometeorological and hydrological knowledge to conserve or improve the environment of arid and semi-arid lands in the sub-tropics:

(i) Maintenance of as much growing or mature vegetation as possible on and in the soil, for protection against sun, rain and wind and to regulate runoff. This requires control of grazing, fire and harvesting of crop refuse as well as planning of crop rotations in relation to seasonal climate, and establishment of wind-breaks.

(ii) Maintenance of soil moisture by increase of rain infiltration and decrease of evaporation through appropriate cultivation and cultural methods matching seasonal rainfall patterns and soil characteristics.

(iii) Collection and storage of surface water conforming to seasonal rainfall and river flow characteristics on scales extending from microcatchment plots to vast reservoirs and flood control systems.

(iv) Rational irrigation and drainage systems and practice based on meteorological and hydrological knowledge which match the evapotranspiration needs of crops whilst avoiding dangers of salinization and waterlogging.

F. WMO AND ASSOCIATED ACTIVITIES

The World Meteorological Organization has diverse activities which are of interest to the ESCAP Regional Workshop and should be briefly referred to here.

1. Desertification is of direct interest to four of the eight Technical Commissions of WMO. These are the Commissions for Agricultural Meteorology, for Atmospheric Sciences, for Hydrology and for Climatology and Applications of Meteorology. Each of these, in its own field, is concerned with the effects of weather and water resources on desertification. The Commissions appoint working groups and rapporteurs to study specific problems. The Working Group on Agrometeorological Aspects of Land Management in Arid and Semi-arid Areas with Sepcial Reference to Desertification is one example.

2. The World Climate Programme, the Global Atmospheric Research Programme and the Hydrological Operational Multipurpose Sub-programme are concerned with investigations of the nature and causes of changes which take place in climate, weather and water resources and the applications of meteorological and hydrological knowledge for the benefit of mankind and the environment. The World Weather Watch Observing System of WMO and the Global Environmental Monitoring System of UNEP are aimed at the establishment of observing station networks and the collection of basic data needed for the investigations.

3. The Monex Monsoon Experiment of WMO and ICSU has direct bearing on the aridity problems of the ESCAP region and the Agrometeorological Project of FAO/UNESCO/WMO has largely concentrated on arid and semi-arid lands of the Near East, Africa and the Andean region of South America.

4. WMO is co-operating with Unesco in the preparation of a technical report on "Hydrological aspects of droughts". The manuscript of the report is being finalized for publication and distribution to all concerned. In addition, WMO is arranging for the preparation of reports on procedures for low-flow and drought forecasting, and on hydrological and water-resource aspects of desertification.

5. Members of WMO are encouraged to appoint members to the Technical Commissions and may be invited by the Commissions to nominate participants in working groups, expert meetings and special surveys where expertise is needed and available.

G. CONCLUSIONS

Prevention is better than cure. At either of these stages there are fundamental meteorological and hydrological aspects of the combat against desertification.

At the initial stages on drylands, degradation of vigour and coverage of vegetation occurs which leads to a less favourable microclimate for recuperation of vegetation when more favourable conditions return. Denuded soil is exposed to intense insolation and rainfall and higher temperatures, evaporation and wind speed which degrade the soil structure and surface and change hydrological characteristics. Moreover, there are resultant changes in reflectivity of the surface and in atmospheric conditions which are likely to lead to an increase in aridity near the soil surface at more than the local level.

Irrigation wholely depends on various types of water supply which are affected by climate in catchment areas. The planning and operation of irrigation systems must also fully take into account both meteorological and hydrological factors as well as plant requirements and soil properties if salinization and waterlogging are to be avoided.

For these reasons it is essential to establish weather and water monitoring stations to provide basic data, and to appoint qualified staff with adequate facilities to carry out meaningful analyses and investigations in national meteorological and hydrological services. The scientists will work in full collaboration with colleagues in agricultural and other disciplines, for the combat against desertification is complex and must be completely based on interdisciplinary effort. The establishment of a national advisory group of all disciplines may be necessary to identify problems, establish priorities and develop projects. The transfer of technology and methodologies from other regions is desirable for rapid progress, but should be used with caution and only after careful consideration of all the factors in local desertification problems.

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III. SOCIOLOGICAL ASPECT

Sociological Constraints and Innovations in Combating Desertification

INTRODUCTION

If action programmes are to be successful they must be relevant to the issues and the people they are designed to help. These may be people living on and making their living from the land, or those involved in related business, industry or government. For the problems of desertification – the social, economic, legal, political and environmental aspects – are so intertwined that nothing but an integrated approach to action can be seriously considered. The concept of an integrated approach is not a new one; it has often been used in a 'nice to have', somewhat academic sense. As used here it is an entirely practical and absolutely essential prerequisite to success.

This general philosophy has many far reaching implications when applied to an action programme. The present paper attempts to outline some of these implications by stressing the complexity of developing an effective programme; by reviewing some problems and constraints and by suggesting positive ways in which programmes may be improved. The latter particularly by appropriately modifying standard approaches and by developing alternative approaches designed to accelerate the effectiveness of action programmes, to halt the spread of desertification.

Throughout this paper there is much concern with standard approaches and the need to develop more innovative, more relevant approaches. This emphasis is easily explained. It hinges on an assumption and an observation. The assumption is that problems are easier to solve if we know what they are. This seems so self-evident as not to warrant further discussion. But its seriousness can be appreciated when one examines a number of international assistance projects directed towards improving the lot of the people in semi-arid lands and finds that an alarming number of the projects have resulted in accelerating the spread of desertification, or as a result of the project, larger problems have been substituted for smaller ones. There are many reasons for a project failing, some of which will be discussed later, but one of them is when the goals of the project are not directed at the existing most critical aspects of the problem which the project was set up to alleviate. One cannot be too clear on problem definition and the definition must be on a broad integrated (social – economic – technical – political) basis. Otherwise how can one expect relevant inputs and priorities to evolve.

The most relevant observation that suggests the need to re-examine present approaches is that after many years of national and international efforts directed toward resolving problems of land degradation (including desertification) the land continues to down-grade. In many of the arid and semi-arid regions of the world this rate of degradation is spreading and accelerating, more and more lands have become permanently less productive and some have gone out of production altogether. The international problem is developing an ever higher profile in terms of public awareness, largely because it is becoming increasingly easier to see and because of the growing severity of some of the by-products of desertification, such as increasingly severe droughts, floods and bush encroachment, unprecedented levels of mortality in domestic stock and starving human populations.

THE INTEGRATED PROBLEM OF DESERTIFICATION

The main causes for the spread of deserts can be stated simply as due to over-utilization in some form, usually by sheep, cattle or other forms of domestic stock, or by dry-land farming, usually for wheat. In desert areas drought (an erratic rainfall) is usually a main environmental component. (Campbell, M.M., 1977) However, as all who are concerned are aware, leaving a description of causes at this level has little chance of providing a basis from which solutions in terms of action can develop.

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A more realistic way of describing causes has been developed in The Integrated Project of Arid Lands (IPAL), a joint UN agencies project in Kenya. Fig. 1, taken from H. Lamprey's report on this project (1978) shows some intertwined relationships between causal factors contributing to desert encroachment in the areas involved. This diagram, as Lamprey recognized, presents a much oversimplified view of relevant causal factors, as will become apparent. However, because of its simplicity it is retained as a useful frame for later reference.

It is the by-products or manifestations of desertification which forms the greatest concern. In Australia for example, these are deterioration of rangelands, falling yields and loss of productive land in dryland farming regions, and waterlogging and salinization of irrigated lands, (Mabbutt, J.A., 1978). Non-agricultural land uses such as mining have contributed to desertification, while the impact of human settlements has also had adverse consequences in sensitive dryland environments. Mabbutt also notes that the problem takes on a distinctive regional character largely because of the human factors involved.

The above definitions and statements made by persons actively working on some aspect of desertification serve to emphasize that the main concerns are with the down-grading process and with the manifestations of this process. Another universally accepted observation is that, in considering desertification we are dealing with complex socio-economic-environmental problems whose solutions require integrated approaches and integrated action programmes.

It seems important to recognize that desertification itself is not the key issue. The heart of the matter is man's inability to live within the capacity of the renewable resource base on which he must depend for his sustenance. So the core issue is, in fact, that resource bases on which we are depending are down-grading, permanently lowering in productivity and for all historical purposes becoming permanently lost to kinds of agricultural and pastoral production or forms of management now available.

INTERNATIONAL ADMINISTRATION AND DEVELOPMENT GOALS

In discussing proposals for action for the United Nations Development Decade, U. Thant (1962) indicated that action by UN organizations consists mainly of drawing up plans for specific projects and assisting with formulating national development policies, although the particular thrusts of each organization vary: FAO intensifies activities relating to the development of agriculture; UNESCO helps mobilize and promote a fuller use of human resources through development of education and science and the spread of information; WHO develops public health programmes; UNEP serves as a co-ordinator on enrivonmental matters etc.

U. Thant emphasized that mobilization of human resources is a pre-condition for development of any sort. "Educated and trained people are always the chief, and in the longer run the only, agents of development." ... "The unutilized talents of people constitute the chief present waste, and the chief future hope, of the developing countries."

Viewed in this way, in planning for action directed at mobilizing human recources in a country, we are in effect trying to improve the relevancy of the social infrastructure in terms of realizing long-term national objectives. This seems as important for the goal of halting and stabilizing down-grading trends and holding firm or improving on present levels of productivity in potential "desert" areas as it is for realizing other national objectives, such as developing rural co-operatives, improved communications or various industrial bases.

In this sense, whatever the targets set within national development plans, any list of aspects to include in mobilizing human resources for development or improved management would involve special attention to the younger generation, education, training and community development.

The younger generation is important for their hands will determine the future of the nation and education must be relevant. Youth employment problems require special attention particularly as countries become increasingly industrialized.

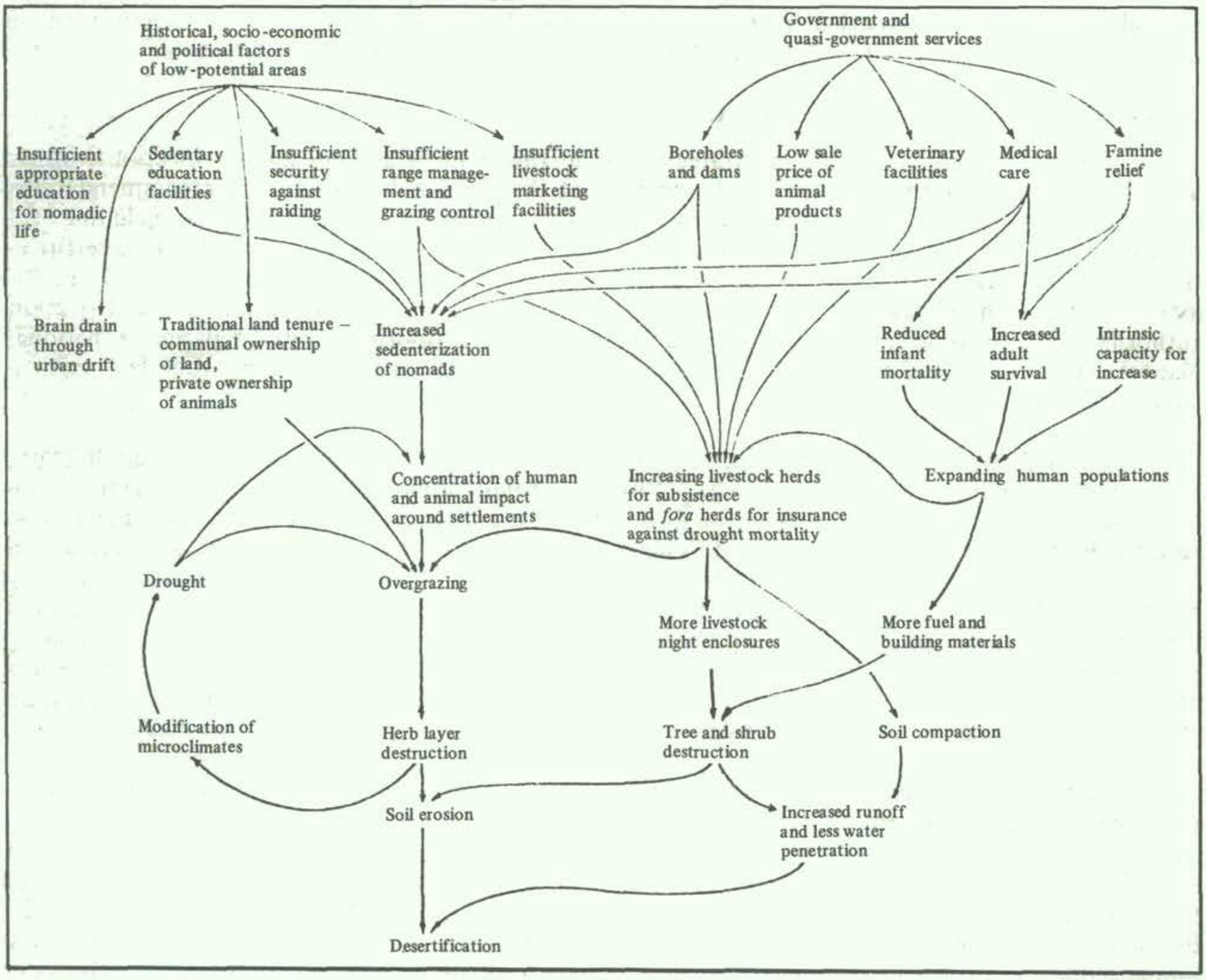

Fig. 1. Diagram of some causal factors in desert encroachment in Northern Kenya (after Lamprey, H., 1978).

Education is essential for producing the necessary human talent and qualified manpower for development. It is an economic as well as a social aspect of development for it is usually the largest single item of public expenditure (Thant, U., 1962). Education, if it is to be effective, must involve careful planning to include all levels from primary and secondary schools through technical and vocational education as well as tertiary education and the supply of highly qualified personnel. In addition various adult education programmes may be relevant, starting with the eradication of illiteracy.

Intensified training for specific tasks has increased in recent years and is likely to become more important in the future. Countries such as India have long excelled in this kind of training and have much to offer third world countries in sharing her expertise in developing such programmes.

Community development in rural areas includes a key element of land reform and, as U. Thant (1962) points out, this involves much more than changes in land tenure or re-distribution of land ownership. In its widest sense, land reform is synonymous with agrarian institutional reform. Land reform measures to be successful must be followed by technical guidance and training of the rural population and other measures to increase agricultural production including the provision of credit and marketing facilities. These and many other forms of follow-up activities, rather than remaining as separate disciplines, can often be carried out more effectively and with promise of sustained progress under the favourable conditions created by community development programmes.

These generalizations help set an international framework but by and large the terms are too general to be effective in particular programmes designed for specific purposes. One such programme is the subject of the present meeting, the UN Desertification Programme: Plan of Action.

UN Desertification Programme: Plan of Action (Anon., 1978)

Specifically, the approach or strategy used in this plan of action on desertification consists of the following: (1) the objectives and principles of the plan are described; (2) recommendations for national, regional and international action are made covering a wide range of issues, including (a) evaluation and land management, (b) industry and urbanization, (c) corrective and anti-desertification measures, (d) socio-economic aspects, (e) drought, (f) science and technology; (3) recommendations are then made for immediate initial action such as (a) establishing a desertification authority, (b) assessing problems, (c) establishing national priorities, (d) preparing a national plan of action etc. and, finally, (4) recommendations are made for implementing the plan, particularly by UNEP.

Throughout the plan of action, emphasis is on the need to maintain an inter-disciplinary, inter-agency and inter-regional approach: UNEP is to follow up and co-ordinate UN regional commissions in turn responsible for co-ordinating, catalysing and executing intra-regional programmes adopted by the member states concerned. The key thrusts of the proposed action are to: keep a continuous inventory of needed programmes and projects and identify gaps; be involved in preliminary surveys and technico-economic feasibility studies as a basis for forming projects and programmes for implementing the plan of action; prepare alternative proposals for mobilizing capital to finance projects; monitor implementation of the plan of action and periodically evaluate and record the results of this monitoring; include monitoring effects of the human conditions as one aspect of the long-term effects of desertification; prepare a newsletter, etc.

The specific kinds of projects to be encouraged by the action programme are: capital investment programmes and projects; pilot and demonstration projects; feasibility studies; training; insurance for peoples at risk; technical and consultative services projects; research centres; project co-ordination; ad hoc working groups; seminars, workshops, meetings etc. In addition a number of teaching and management manuals are to be prepared as well as a world map of desertification and a list of concerned organizations. Monitoring itself is seen on a broad basis and, in monitoring the human condition, this includes the variables of population, human and environmental health, food, human settlements, education, socio-cultural patterns, man as a land user, production and productivity.

The plan is summarized here because, for this workshop it is the single most relevant example of a series of standard approaches by an international organization. Its strategy, objectives, recommendations and indications of priorities for general emphasis and for project development all make sense as described. However, in the context of this paper the plan is regarded as a skeleton, a list of guidelines, each of which have to be re-examined country by country for relevance to the particular conditions characteristic of that country. Each point, no matter how convincing in terms of presenting an international programme, must be regarded as a base idea which usually must be modified and re-stated in ways that make most appropriate sense for each country.

Problems

"In their relations with nature, as in their relations with their fellows, human beings appear to be poor students of history, Despite the all too visible diorama of ruined landscapes and abandoned civilizations, mistakes of the past seem time and again to serve as models instead of usable lessons. Deaf to the almost daily warnings of some looming new ecological threat, governments and individuals rarely change their habits accordingly... How can people destroy the basis of their own survival?" (Eckholm, E.P., 1976)

In this paper we are considering what is basically one major problem: the seeming inability of man to profit from his own past or ongoing experience. Viewed in this way other problems are subsidiary, supporting, complimentary, or interesting but tangential.

Importance of a historical perspective

Normally land-use changes are slow in evolving and when they do come, recognition of their full impact may be long delayed. Some changes are swift, but in major changes it takes time for the impact to work its way through the total ecological, social, economic and political environment.

In many areas traditional destructive patterns of use are well known and continuing. For example, in the southern Sahara a common pattern of pastoral use setting the stage for desertification was:

1. Over-grazing (too many livestock for the existing vegetation to support).
2. Consequent decrease in available pasture.
3. When grasses became too scarce the herdsmen climb palatable trees, cutting down branches so stock can feed on the leaves.
4. At the same time, unpalatable trees are also cut for firewood.
5. The end result is loss of both perennial grasses and trees and, consequently, shifting sand or bare rocky ground and abandonment of the land by humans.

Unfortunately, precisely this same pattern of use is still followed in marginal areas of the Sahara today and it still accelerates saharanization, as it so effectively did in the past.

In dry and semi-arid lands one ecological characteristic in particular has insiduous and long-term implications. Oversimplified, this involves the slowness with which vegetation can recover to a former level of productivity once degradation has passed a certain threshold or point of no return, even following the complete removal of domestic stock. If the upper richer layer(s) of soil have been removed it may never be possible to achieve former levels of productivity. In one Zimbabwan area, where the above mentioned threshold was passed seventy five years before a study was made, it was demonstrated that the land in the vicinity of the formerly heavily over-grazed area was still down-grading. It was estimated that, in the absence of expensive reclamation measures it would take between 150 and 300 years before the land could stabilize once the cause (over-intensive use by domestic stock) was completely removed.

This has important implications in considering the significance of the impact of various kinds of changes on an environment which results in lowering productivity. For if local thresholds are passed the after effects may continue for many decades or hundreds of years after the time of the historical change. This in turn can vastly complicate the business of relating present trends to causes when, for example, major causes may be several and spaced a century or more apart.

Assistance projects as a means of accelerating desertification

Newly independant countries and other Third World countries are increasingly asking for help from bi-lateral and international sources. Help and advice is usually given by European and American experts. Once the advice is accepted and implemented this all too frequently accelerates the spread of desertification, rather than halting and containing it (Riney, T., 1963). Large-scale human starvation in West Africa was predicted in reports to international organizations in 1963 and 1964 by the same author. And human starvation in fact took place in West Africa, the area for which the predictions were made, in 1972 and 1973.

And in 1973, international and bi-lateral assistance organizations met in Rome and considered types of projects desirable to prevent such dramatic consequences from recurring. Unfortunately, the conference recommendations included exactly those kinds of projects which had already accelerated desertification and which would continue to do so. Some of these are still included in recommendations in the Plan of Action for the UN Conference on Desertification. And desertification along the southern Sahara continues.

Three examples of the kinds of projects involved in accelerating desertification were:

1. Water development by a bilateral organization in northern Senegal, which resulted in heavy over-grazing by the cattle, camels, sheep and goats of the suddenly inflowing semi-nomadic people. Three years after water was made available, land was already useless for domestic stock within two kilometres of the waterpoints and was rapidly down-grading elsewhere. Consideration was already being given after this short time to abandoning the 10,000 sq. km. project area. Similar water development troubles were observed in Upper Volta, Chad, Dahomey, Nigeria, Kenya and Botswana, to name a few.

2. Stock inoculation and stock improvement campaigns led to increasing numbers of animals, which was the objective of such projects and in this sense was a success, initially. But increased numbers without increased food intensifies over-grazing and accelerates the down-grading of vegetation and ultimately desertification.

3. Village amenities were provided in an area previously without villages by a government which insisted that rural people move to the proposed village sites by a certain date, This resulted in such rapid and artificially high concentrations of people and livestock and had such a devastating effect on the surrounding areas that the scheme had to be abandoned a few months after its inception.

Although only three examples are listed, there were many more. All had in common a proposal which, when put into effect, stimulated a temporary increase in numbers of livestock. But the numbers were too many for the natural vegetation to support on a permanent basis. And in at least one project livestock were over-stocked even before the project designed to increase their numbers was started. Another common element in these projects was that an over-specialized technical approach had been used in identifying, formulating, staffing and implementing the projects.

The same report further suggested that:

1. Any projects that improve the environment for groups of people traditionally dominated by neighbours who would (traditionally) not hesitate to move in and destructively exploit the improvements for their own use should be very carefully planned indeed.

2. A government-enforced, large-scale change in a pattern of human occupancy or in livestock migration routes is one of the most difficult operations to achieve successfully. In every instance observed in a survey made in twenty countries in Africa south of the Sahara, this type of project or operation had initiated large-scale troubles in the newly occupied or newly utilized areas.

Action programmes have many facets and problems can occur in implementing any aspect of development: problems great enough to seriously retard or arrest altogether either a broad action programme or an individual project. Let us now consider briefly some of these problems involving the effectiveness of development.

The technology trap

S. Hill (1981) has emphasized a general difficulty which he feels underlies many problems of development. This is essentially the difficulty that underdeveloped countries are inescapably bound to an internationally competitive context of advanced country dominance. He warns that unless there is a greater concentration on bringing the lesser developed country's technological capability up 'by the boot straps' and to integrate technological knowledge with local conditions, then he feels that no matter what structural and economic changes are implemented indigenous industry will continue to be contained by the control of foreign investors. As dependence on foreign aid grows deeper, local development may be seriously biased towards the demands of an urban middle-class elite, and both international and indigenous inequalities are likely to expand rather than be alleviated.

The assessment gap

A related problem has been identified by R.D. Medford, former director of the Fiji Development Bank (Medford, R.D., 1979), who is concerned with the large discrepancy between highly industrialized countries and largely rural developing countries in terms of their ability to make pre-development assessments. He calls this "the assessment gap". This gap is essentially the lack of ability to cope with technology. The discrepancy can be more precisely expressed by listing specific gaps formulated by a number of small countries in the Pacific Region as: (a) explicitly formulated science and technology policies do not exist at national or regional levels, (b) no established non-vested interest technical institutions exist in the region with established ties to planning and development centres operating at a national level, (c) local training of technological cadres is inadequate, (d) no conceptual system or means of keeping up to date with relevant technological innovations elsewhere in the world is present, (e) such pioneering organizations (externally funded) designed to encourage or support major technological thrusts have not been administratively or executively structured so they become locally dominated, (f) no professional associations of technicians or scientists exists which approach international standards; there are scant relevant local publications, (g) lack of training of skilled managers and (h) the preservation of knowledge about the region's technology has not been institutionalized.

Problems of organization and administration of agricultural services

In countries with desertification problems administrative machinery is often inadequate to mount a successful national programme to combat desertification.

As L.L. Barber and S.T. Farouky (1964) have observed when examining problems of organization and administration in Arab states, such problems can be of several different types. For example: (1) fragmentation of responsibilities among different departments leading to duplication and lack of co-ordination; (2) problems caused by poor internal organization and management; (3) lack of adequate staff.

Obviously each of these difficulties make it hard for a country to mount an effective co-ordinated effort toward combating desertification.

Extension work in general

Problems encountered in planning or undertaking extension work in arid regions have been identified as: illiteracy, conservatism, the difficulties of communication, inacessibility of materials, prejudice against government officials, administrative and financial problems and shortage of trained extension personnel (Behravesh, Z., 1962). Specific difficulties are also encountered when attempting to introduce technical innovations into arid lands.

Religion

The Islamic religion is perhaps the most widespread religion in areas susceptible to desertisfication. Its teachings can provide enlightenment and motivation for government leaders and planners. There is a feeling in these regions that the people of the countries concerned must have the faith reguired to work and save until their efforts bear fruit. In this connection the International Islamic Economic Organization has made the following statement on achieving economic progress, as quoted by B. Higgens (1953):

> "In the economics field we advocate a system in which prosperity and development is the security and guarantee for the personality and well-being of all. We consider that an under-developed or a backward area is a challenge to the conscious and enlightened self-interest of the whole world. Within the brotherhood of Islamic countries we recommend applications of economic co-operation and mutual exchange of knowledge and expansion of trade. The directive principle of our social policies, based on the timeless teachings of Islam, is the well-being, prosperity and the dignity of the common man, so that the personality of every individual is afforded full scope to develop"

At the same time, as with any of the major religions, many off-shoot sects exist in remote areas. In 1962, I had some acquaintance with several small groups of Islamic nomads in central Tcbad. They grazed cattle and sheep, the household was transported by camels and the male family leaders rode horses and carried quotations from the Koran burned on slabs of wood attached to their saddles with leather thongs.

Starvation had hit the region heavily in the previous unusually dry year and the families I contacted were each composed of the survivors of six or seven other families. Their herds were small and likewise represented the combined survivors of several former herds.

I was searching for some element in their social environment, or some source of motivation which might be useful in starting a trend toward improving their condition. After lengthy questioning, it became clear that the question of improving their own lot, of making conditions better for their families, even the question of improving their chances for their own survival was simply not relevant, for what happened would happen and was the 'will of Allah'. In their view there was not only nothing they could do about modifying their own fate, there was no point in trying. The question of legislating against over-grazing was not raised. It would have been equally unproductive, for they lived outside the laws of the land. In any case there was no possibility of enforcing laws in that remote region.

The only authorities they listened to, and whose advice they respected, were their religious leaders. It was, therefore, strongly suggested that, in any future assistance or development work in this part of the Sahara, the local religious leaders should be closely consulted and if possible involved, even in the very early stages of project preparation.

Communication and co-ordination

The major problems in terms of mounting an effective national programme to combat desertification are often problems of inter-departmental communication and co-ordination. For example, a workshop on organization of agricultural services in the Arab states (Anon., 1964) found that the greatest problem hindering improvement of agricultural services was the lack of unity and co-ordination between departments.

This problem was further underlined as a result of an integrated and multidisciplinary survey requested by the FAO Regional Office for the Middle East, the object of which was to prepare an integrated report defining for the region the major marginal land problems and associated problems (Riney, T., Reklewski, M. and Solomon, E., 1973).

In this way it was hoped not only to define the major problems but to be able to assign priorities for action by discovering the major constraints to action which should receive priority attention.

The major marginal land problem was easily defined as desertification, through over-grazing and speculative dryland farming. Little difficulty was found in recognizing and describing major economic constraints, although these differed considerably between countries for two of the countries visited were poor and two were oil-rich. And several sociological constraints were identified, particularly in the fields of administration, training and co-ordination.

It became very clear that, although the problem of the spreading areas of desertification was of vital concern to the governments and was the reason for the survey in the first place, the major constraint in implementing an effective action programme on the ground was sociological. Each country visited had identified, without prompting by the survey team, lack of co-ordination between government departments as the major constraint to moving forward with effective action. And two of these countries were convinced that, preceding improved co-ordination, improved communication between departments had first to take place.

The survey concluded that, unless communication and co-ordination between government departments could be considerably improved, external assistance, in terms of the formation of the normal kinds of projects then being proposed, was likely to be wasted. Priority attention first had to be given to working closely with the governments concerned in developing means of improving co-ordination between departments as a prerequisite to further development assistance.

Unfortunately, policies and politics of international assistance to Third World countries, at that time precluded such a proposal being seriously considered. But the conclusion still seems valid and must eventually be taken more seriously if we will improve our international capacity to profit from our own past experience.

Land reforms

The breaking up of concentrations of lands in the hands of a powerful few and its reallocation to many, obviously involves major administrative, legislative, and usually political changes, and is too complex to discuss in the present paper. It is, however, relevant to note that in a recent Monthly Commentary on Indian Economic Conditions, M.A.S. Rajan (1980) has stressed difficulties in implementing land reforms. Dissatisfaction, he feels, arises from reviewing the extent of enforcement of enacted policies, or the pursuit of declared intentions, and from studies of the after effects of such reforms. He notes that dissatisfaction in some countries has been so great as to lead to speculation whether such reforms cannot be by-passed altogether.

While land reform in an important subject in itself it is mentioned here as an example of large-scale rapid change and, as Riney (1972) has suggested, socially and ecologically, rapid large-scale changes are best avoided and gradual development is much to be preferred. Large-scale development brings into play various inter-compensatory mechanisms or homeostatic mechanisms which, in turn, produce useful evidence for evaluating trends. While changes are slow, these kinds of evidence can simply and quickly be recorded in time to recognize and arrange for a reversal of an unfavourable land-use trend. Rapid development, particularly if on a large scale, can be ecologically dangerous. If high numbers of animals occupy land of low carrying capacity, changes can be so rapid that by the time evidence of the trend is clearly appreciated by land managers, consequences may be catastrophic and irreversible. In the example given above involving water development for semi-nomadic people in Senegal, this over narrow approach to development produced not only disasterous ecological consequences but social and economic difficulties as well. The families settling the newly opened areas were forced to move elsewhere by the desertification process their normal activities accelerated.

The Australian Country Report for this meeting elaborates two sets of factors which are considered responsible for accelerating desertification processes. The first set involves factors responsible for over-grazing of the native vegetation. The second set comprises factors which operate through people – the social, traditional, political and economic forces which shape land use and management. The authors make it clear that they believe that the 'social' forces include the basic causes of desertification in Australia. And they further note that, although the second set of factors is recognized as most significant, they have yet to be effectively analysed or countered and seventeen specific constraints are identified.

For each of the problems discussed above an attempt was made to alleviate a development or land-use problem following some standard approach or strategy. Standard approaches, as used here are tried and tested strategies which are commonly used. There is no question that some measure of success has been achieved by these approaches. The action programme to combat desertification itself follows a standard approach, and like other standard approaches it is an approach designed to work. The dilemma Australia faces, and I suspect other countries face as well, is that we are caught in the trap of standard approaches, while at the same time recognizing that exactly these same approaches have not worked particularly well in our own country or elsewhere. And, recognizing that, at the same time these accepted and sensible methods are being carried out, entirely too much of our land is steadily moving from productive, to less productive to permanently lowered productivity year by year. The desertification process continues in spite of our recognizably good intentions.

POSITIVE APPROACHES AND STRATEGIES FOR IMPROVING NATIONAL AND INTERNATIONAL DESERTIFICATION PROGRAMMES

The survey team mentioned above (Riney, T., et. al., 1973) noted that the more they learned about the specific marginal land problems in the countries visited, the more complex the regional problems and solutions appeared and the more difficult it was to make recommendations that a country could use as practical guidelines for arresting down-grading trends. Problems are far greater, more complex and cover much broader fields than any publication has, or perhaps ever will, describe.

With this in mind, if we are to be practical about developing action programmes there is certainly no point in searching for a single approach or a single solution that can be applied to all countries in combating desertification.

Because of the slowness in profiting from past experience, because of the demonstrated difficulties most countries still have in achieving integrated and co-ordinated programmes or projects, it seems sensible to experiment with developing additional inputs along at least two different but complimentary lines.

Firstly we can put effort into making standard approaches more effective and more relevant to arresting down-grading lands. Secondly, we can try different approaches which may supplement or complement standard approaches now being used.

As a framework for improving on standard approaches, consider several basic aspects of development that seem to be accepted as worth improving. For example, the needs: to achieve a better integration of social, economic and environmental aspects in development; to profit from past experience; to more appropriately involve people at the grass roots level; to improve the effectiveness of our local, national or international development projects. But general acceptance of such generalizations will not necessarily result in better results on the ground.

To enhance standard approaches it is useful to consider more specific ways and means of improving on one or more of the basic elements of an action programme. The principle emphasized is that, just as we know that development problems are multiple-faceted and complex, so we must assume that their solutions may be multi-faceted and complex. Practically, this means simultaneously working along as many relevant fronts as possible.

First consider legislation as a means of making desertification programmes more effective. Then three closely related concepts or approaches which are proving useful in various countries. And, finally, a review of serveral specific elements of national programmes, selected as appropriate for strengthening and improving.

Legislation

In recent years there has been a growing national and international awareness of the lack of assessment of the impacts of rapid technological changes on the surrounding environment. Such results have long been accepted as normal, as the unfortunate outcome of technology and as necessary for an increasingly affluent way of life. Now, however, an increasing number of people question the notion that environmental deterioration is a necessary result of expanding technology, or of development itself. This process of questioning has in many countries led to direct confrontations between the forces of expanding technology and citizens concerned about the deterioration of their own environment. There is an increasing trend toward realizing, somewhat painfully in some quarters that .... "people have the right to live in a well-managed environment in which a continual and conscious effort is made to enrich that environment and to prevent it from deteriorating". (Chapman, R.J.K. and Lake, P.S., 1972).

The fulfillment of this realization will rest upon decisions which aim at managing resources with full consideration for the anticipated impact on the environment.

In 1972, in Tasmania, Chapman and Lake (1972) observed that citizens concerned with environmental degradation were unable to have these rights recognized. Although there was legislation covering various kinds of environmental enterprise, most of the legislation was impossible to police or enforce. As a result, campaigns against environmental degradation had to be carried out through the use of the media and the induction of changes in public opinion, and not by resorting to court action.

In the United States especially the courts have become the arena where citizens have won the right to enjoy a clean environment. However, in most countries the means for environmental protection are both weak and scattered and there is an obvious need in many countries for the enactment of comprehensive environmental protection legislation. This in turn raises questions of what kind, how much and initially how sophisticated should the legislation be.

A question which has troubled many developing countries is whether one should proceed to enact legislation which may be eventually required for the long-term maintenance of renewable resources, or should one confine the legal constraints only to those which may be enforced in a practical way in the short term and consider more comprehensive legislation at later stages of development.

To resolve this question it may be useful to consider legislative solutions not in isolation but to concentrate more on an approach or process to initiate or accelerate trends moving in the direction of a long-term solution.

It is suggested that legislative changes in the form of Acts or Regulations will be needed in most semi-arid regions. These may include specific regulations governing the use of available water and pastures. Other forms of legislative action can involve creating new organizations, adding to or re-assigning responsibilities within existing departments (for example, extending extension programmes at some appropriate grass-roots level or developing legislation controlling re-settlement schemes). Other forms of control or strategies leading to improved management may be considered as supplementary to such legislation.

One commonly encountered problem seems worth special emphasis. Lack of co-ordination between government departments has been noted as a major constraint to development of land uses on a sustained basis. Therefore, one obvious recommendation is for countries to give serious attention to developing some improved means of maintaining communication and co-ordination between relevant departments concerned with down-grading lands.

A number of countries, including those as different as Zimbabwe and New Zealand, have discovered that one way this can be done is by legislating to create a Natural Resources Board, or Council. While the name varies in different countries, the principle characteristics seem to be:

- While the board or council is created by an Act and supported by government funds, it is separate from any government department. Some Boards have the right to co-opt assistance from government departments for a specific task in hand.
- The president or chairman of the Board has free access to government departments at the highest levels (i.e., Minister and Head of Department).
- The Board is composed of representatives from both government and private sectors and terms of serving on the board are staggered to maintain maximum continuity. Boards composed only of government officers seem less successful than those whose members include private individuals from the agricultural and business communities.
- Such Boards normally maintain a public relations and extension unit and are free to publicise any issues they feel should be brought to the attention of either the general public or a particular government agency.
- Ideally such Boards establish particularly strong and special links with primary producers, relevant government departments and private organizations.

In some countries the Acts creating such Boards also invest them with the power to enforce malpractices. However, in my experience the most successful of these organizations rarely use this power but accomplish their objectives by means of making information freely available throughout government and to the general public.

Such organizations serve a kind of watch-dog monitoring function. In democratic countries their guiding principle is that, whilst individuals have the right and the freedom to own and to use land for their own purposes, this does not include the right to permanently lower the productivity of that land or to destroy its capacity for gainfull use by future generations.

This principle is not only an ethical consideration, it is a practical concept, a guideline upon which governments can base legislation and departmental action to assist in maintaining the renewable resource bases on which individual citizens and governments depend. This principle is particularly important for any country concerned with down-grading lands.

For those countries in an early phase of developing environmental awareness and conservation servicing activities within government, the creation of some form of National Renewable Natural Resources Board can ensure a continuing look at conservation aspects of land use and land-use practice, a continuing assessment of problems of the moment, and continuing concern over ways and means of improving communication and co-ordination between government departments on major national issues such as desertification. In other words the creating of such an organization can ensure that a constant effort be directed toward initiating and encouraging various trends toward arresting desertification and bringing something better for the country in its place.

S. Brubaker (1972) suggests that in developing solutions involving legislation it may be helpful to split the suggestions into short- and long-term categories.

In the short term his concern is with situations in which forseeable technical research, definable regulation, economic incentives and systems of organizations can make a real difference. Such measures, he feels, have the potential of allowing us to meet most of our problems over the next 20 or 30 years.

In the long-term setting an appropriate course is more difficult for no one can lay out policies and enact legislation sufficiently comprehensive and relevant to deal with the problems of tomorrow. The Brubaker common sense suggestion is that if the rules and the technology that we now have are ill-suited to our changed circumstances, the constructive response is to amend them rather than seek out scapegoats and flay them to no real purpose.

As participants will be aware, there has already been good progress within the Asia and Pacific Regions. For example at a recent Technical Meeting of the South Pacific Regional Environment Programme, the meeting concluded that ... "The way in which new countries of the region were incorporating environmental objectives into their constitutions and other basis statements of policy could be a lesson to the rest of the world. The keenness for finding regional legal bases for environmental protection promises strength for the region". (Anon., 1981).

The concept of basic needs

The concept of basic needs is useful mainly in planning, where changes in land use or development is desired. Basic needs may include food, clothing, shelter, education, health, water and sanitation. Some include non-physical items on the list such as employment and participation in the decisions which affect ones life. As R.J. Szal (1980) points out, there is no single set of basic needs. "The definition of what constitutes them will vary from one country to another, and to the extent possible, the people themselves should be the ones to define their needs."

Two approaches are suggested by R. J. Szal (1980) for implementing a basic needs strategy. One approach suggests setting criteria for developing basic-needs activities within national or regional programmes. In considering proposed activities one should, for example, consider the extent to which the activity might: (a) raise incomes of target groups through employment creation...to reach a target income over a specified period, (b) if in achieving these targets a direct contribution will be made to achieving core basic needs such as nutrition, health, education, housing and water, (c) increase production of other basic goods and services purchased by low income groups, public sector and communal agencies, (d) enhance decentralization, participation and self reliance.

Additional desirable characteristics of proposed activities should, to the extent possible, use simple equipment, have relatively small capital cost, require low skill levels and use local materials. Throughout, in developing countries, techniques and procedures must be kept simple. Analytically speaking such less sophisticated techniques may be inferior, yet operational feasibility may dictate that techniques, such as input-output tables, be avoided. Based on such considerations specific programmes have thus been developed and were reported on at the ILO conference mentioned above.

Another way of implementing the concept of basic needs is through the use of product path analysis, whereby one separates the components of various development programmes so as to consider for each segment the extent to which they contribute to meeting the requirements of the various target groups. The process consists of first identifying the precise components of basic needs. These components are then compared with current assumption habits. The result is either shortfall or overconsumption and this forms the point of departure for planning with product path analysis.

These approaches may be useful in planning and in setting priorities, but, inevitably, trade-offs are usually required. Critics of the basic needs approach argue, for example, that the approach will result in a reduction of savings and in productive investment.

On the other hand proponents of the basic-needs concept argue that better nutrition, housing, health, education etc. are also investments but in human capital; these investments result... "in a more productive labour force, and any reduction in monetary investment, whatever its consequences on (economic) growth, are more than offset." (Szal, R.J., 1980).

Szal also attempts to answer criticism of the basic-needs concept in terms of the way growth is perceived:

> "Just as the basic needs approach is aimed at turning conventional planning on its head, so too must the concept of economic growth be viewed from a different perspective. The purpose of growth is an improvement in the welfare of all the people, and when viewed from this point, any hypothesized trade-off between basic needs and (economic) growth may turn out to be a mirage. When properly planned and implemented, economic growth will be the result rather than the goal of a basic needs strategy."

The self-help approach to rural development.

Most of the programmes for assistance are based on a relatively narrow view of rural development seen through the eyes of one or another group of specialists. Most are based on the implicit assumption that rural development can be initiated only by outside intervention and by the introduction – even the imposition – of modern production technologies (Coombs, P.H. and Ahmed, M., 1974).

The proponents of the self-help approach begin with a somewhat wider concept of development and with somewhat different assumptions about how it can be induced. Rural development is seen as involving transformation of all economic, social, political and cultural institutions, processes and relationships in a rural society. The main obstacles to such transformation are regarded as historically rooted fatalism, dependancy and lack of self confidence of the traditional rural people. Consequently they believe that an initial requirement is to start broad educational processes that would alter attitudes, raise aspirations, and self confidence and encourage individual and community initiatives. Recognized also is the need to create greater political awareness and participation by villagers and greater community co-operation, strengthening the local democratic institutions and broadening the leadership base. While the importance of modern expertise and other forms of assistance coming from outside was acknowledged, they were concerned that such help be in response to expressed local needs and desires – as part of an "enabling process" – rather than one way intervention from the top down.

As Coombs and Ahmed (1974) summarized: "The proponents of the self-help approach to rural development base their strategy on a more humanistic and less technocratic theory of development. They respect the power of science and technology but put their basic faith in the adaptability of human beings. Simultaneously, they are trying to overcome an inherent difficulty of a community development approach: mainly that of meeting local needs that are in fact more broadly based than the articulated demands of the more affluent rural minority who are in a position to control such an approach."

With these thoughts in mind proponents of the self-help approach place heavy reliance on a somewhat different kind of education, more broader, more subtle, more inner directed than that associated with formal schooling. The core of their approach is the basic principle that learning comes from action, that development itself is educational, and that villagers learn best from teachers with the same background.

It may be useful to give as an example a broadly based approach to rural development at the village worker level for Medchal Panchayat Samiti near Hyderbad. These village workers consist of young men or women, high school graduates, typically of rural origin and with two years of specialized training and apprenticeship in the multiple aspects of community development, including agriculture, health, home economics, local self-help projects and savings schemes. These Village Local Workers live in the villages among the rural people and might serve as many as 10,000 people in 10 villages, acting both as their agent to the government services and vica versa. For problems beyond their technical grasp they can turn for help to the specialists at the Block or District levels.

The agenda, as shown by Coombs and Ahmed (1974) is:

A. Agriculture

Distribution of improved seeds

Supply of fertilizers and pesticides

Distribution of improved implements

Promoting Japanese method of paddy cultivation

Loan schemes – wells, cattle purchase, crop loans, electric motors for pumps

Rural manpower programme

Fruit development scheme

Intensive manuring scheme

Soil conservation scheme

Intensive vegetable cultivation scheme

Minor irrigation – restoration of tanks and wells, construction of small weirs and dams

Animal husbandry schemes – livestock census, artificial insemination, veterinary service

Fisheries – construction of fish farms, breeding and distribution

B. Roads

Construction of feeder roads, cross drainage, etc.

C. Health and rural sanitation

Health centres, family planning clinics

Drinking-water wells for schools and villages

Vaccination

Maternity centres

Applied nutrition programme

D. Education

Provisions for teachers, buildings, school supplies etc. for 115 primary schools

Pilot scheme for compulsory primary education

Adult literacy centres – one per village

Youth clubs

Libraries, provision of community radio sets

E. Womens programmes

Clubs

Tailor and dressmaking centers

Improvement in cooking and sanitation equipment

F. Small industries

Survey of small industries and artisans

Provision of workshops

G. Joint action with co-operatives

62 multi-purpose; 8 milk supply; 5 fishermen's; 18 Toddy Tappers' societies.

Coombs and Ahmed (1974) report that almost two decades after the programme was launched the evidence and testimony as to its effectiveness is mixed. On the one hand, in its early years there was a great surge of enthusiasm both by community development workers and villagers. It brought an unprecedented infusion of new resources into the countryside and inspired a large number of self help projects. Throughout India community schools and village halls were constructed, roads built and paved, water wells dug and protected, vegetable patches planted, sewing and youth clubs opened and so on. A new image of the government as a source of help and service was created and villagers began to see for the first time that agents of the government were there to help them and not simply to demand taxes and enforce regulations. Another important achievement reported was the creation of the "panchayat" structure as an instrument of self-government and self-expression for the rural population.

On the other hand, in spite of these positive accomplishments, after the first decade of operation the community development programme had not significantly altered the basic conditions of life in rural India. Abject poverty, malnutrition and ill helath, indebtedness and the worsening of the food crisis all of which demanded a larger production of wealth from the land. In this respect the community development programme is reported to have had little impact.

What seems particularly important to anyone with experience in developing effective projects in developing countries (in putting ideas and reforms into effect) is the consciousness that new ideas are more acceptable to people when they come not from outsiders but from their own kind of people and especially those with whom they grow up and trust. People are the most important factor in good watershed management (Singh, G., 1971) and resource development, and in halting and reversing the process of desertification. But if we are to profit from past experience we must also be aware that an appropriately contrived solution may work beautifully in its early stages and then dwindle in effectiveness. This may happen for a number of reasons but is commonly related to changes in the community itself. The initially desired changes inevitably have their impact on the community and as the community changes so its priority needs change and old objectives become irrelevant as they are met and as new priority needs emerge.

The "grass-roots" approach – two examples.

In agricultural extension it is common to hear extension workers refer to a basic concept in their work, the "grass-roots" approach to extension and development. Loosely interpreted, this simply means that to develop an effective programme one must become closely involved with the people on the ground where the problems are: those actually doing the grazing or the farmers. But the grass-roots approach can take many different forms, and can vary from including a few grass-roots elements in a development programme to planning the entire programme or project from the ground up.

The Comilla Project: A good example of the latter approach is an interesting version of co-operative education illustrated by the well known Camilla project in East Bengal, now Bangladesh. This experimental undertaking by the Academy of Rural Development at Comilla, in 1959, aimed at providing an integrated attack on the obstacles to agricultural development in a selected thana – an administrative unit of about 100 square miles with more than 200,000 people, mostly subsistence farm families – by means of a planning and management structure in which the local residents operating through co-operatives would play a leading role. This is particularly interesting because it involves an extension service in which much of the effort moved from the bottom up, instead of from the top down. Starting with effort at boosting agricultural production, the educational structure that was established actually provided a framework for a wider array of educational efforts serving a broad range of rural development needs.

The essential innovation of this Comilla project was that the village people chose one of their own number to serve as their educational liaison with outside sources of knowledge relevant to their needs (as they saw these needs). This was part of a broader set of procedures for creating governing and operating local co-operatives developed jointly over a period of time. Under this protocol, villagers agreed to (1) organize themselves, choose a chairman and become a registered co-operative society; (2) hold weekly meetings with compulsory attendance of all members; (3) select a man from the group and send him to the Academy once a week for training so that he could be the organizer and teacher of the group; (4) keep proper and complete records; (5) use supervised production credit; (6) adopt improved agricultural practices and skills; (7) make regular cash and in-kind savings deposits; (8) join the central co-operative association of the thana; and (9) hold regular member education sessions.

The village co-operatives thus became the prime agencies for agricultural improvement and rural education. The "organizer" and a similarly chosen "model farmer" became the key agricultural teachers in their own community, rather than an outside extension worker. These representatives regularly came to the Academy for training and received expert advice and assistance on problems identified through discussions in the village co-operatives society.

Later, as need arose for a variety of common services for small local co-operative societies, other groups were formed and operated in conjunction with the first formed co-operatives. One of these groups was the Thana Central Co-operative Association, which provided training in skills in response to specific needs. For example, school teachers and other literate villagers were trained to maintain the accounts of the village co-operatives. Young men from the village were trained as tractor drivers and irrigation pump operators. A machine shop was set up for repairing tractors and other equipment and for training mechanics.

Up to the time of its disruption by the war of independence in late 1971, the Comilla project had a record of impressive accomplishments. It had demonstrated a way to give local people and local level public administration a larger voice and practical role in rural development, and a way of combining the rural services of distant government agencies, including education services, into a more cohesive and effective package. Comilla had also shown that a two way channel of educational communication between villagers and outside sources of knowledge and expertise – using as go-betweens teachers of their own choice in whom they had high confidence – can be more effective than the more familiar one way top-down extension model. The Bangladesh Government is attempting to put these lessons to use on a nationwide scale, according to Coombs and Ahmed (1974).

A 'development wheel': Another "grass-roots" approach to planning is being developed by S. Roughan (m.s.) in the Solomon Islands. Although details of this work are still unpublished, Roughan's approach seems worth mentioning even in general terms. It is relevant in the sense that he is reported to have had some success in involving villagers in planning for their own development (A. Davis, Pers.

Comm.). One of Roughan's observations is that too much development talk and action has been about one thing – material growth. His scheme tries to balance this common concept by bringing in two other needed growths: personal and society.

Roughan sees human development as steady improvement in personal, material and social needs. If development is moving toward satisfaction of all of these needs then a society is going to be strong politically. It is able to participate in the public life of the nation, the life of politics. If any of these three aspects of growth is weak, then the political life of that community will be poor.

In implementing these kinds of development Roughan's practical approach is for planning to take place at the village level. He uses the device of a wheel figure (called a Development Wheel) to show that personal growth, material growth and growth of society, all three must come along at the same time. Different subjects considered provide names for the many spokes of the wheel and the spokes themselves are grouped into three segments.

Under Personal Growth (one segment) for example, subjects (labelled spokes of the wheel) such as self-respect, self-reliance and personal qualities, identity and security are considered. For example, under the Self-reliant spoke the village meeting rates itself high if it if possible to follow one's own ideas and plans by using one's own means, e.g. copra making (planting, harvesting, making corpra, selling), all done from people's labour, skill and know-how; not relying on others for one's living. The opposite of this (the lower rating) would apply to villages dependent upon others for food, housing and other basic needs.

Under Material Growth (another segment), nutrition, shelter, health, money, land ownership, land use, transportation, communication and equality of growth are considered. Under the Transportation spoke, for example, it is recognized that it is important sometimes to be able to travel quickly and cheaply to nearby towns, to hospital or for business. If this is possible the rating is high. Low ratings are given where it is difficult or expensive to travel to necessary places.

And under the third segment, Society Growth, subjects considered are participation, solidarity autonomy and equity. Under Solidarity, for example, if village people share major values of society and act from them; if more sharing than taking occurs and sharing of food and labour is common, this gets a higher rating than those villages where money is far more important than human relationships.

For each of these subjects a group of villagers is questioned, with the interviewer and the large pre-drawn and labelled wheel in front of them. A scoring system is explained and after each subject (spoke) is discussed each individual gives a scoring from one to ten and the score is divided by the number of participants to give an average. This is then marked on the relevant spoke of the wheel, low scores being closer to the center; higher scores closer to the rim. By showing the completed wheel after the exercise, with all the scores connected with straight lines, the village person has a better feel of what village development is all about than many words spoken about it can give.

The procedure seems effective for the Solomon Island villages where it is being tried and it will be interesting to see to what extent this or similar modified approaches may be effective in other regions.

Several Programme Elements Selected For Priority Emphasis

Defining problems and setting goals

In Australia, and I suspect this may apply to some other countries, if we concentrate our efforts on an anti-desertification programme we would not be thinking big enough, even in terms of halting desertification processes. Our major concern is with lands down-grading, particularly those declining in productivity under existing forms of use or management. In these terms such lands are marginal to lands being maintained at more or less stable levels of productivity and are increasingly being referred to as 'marginal lands'.

For example, one of the aspects of integration, particularly where water is an element of concern, as it is in our deserts, is to consider planning for improvement and development on a watershed basis. Some of our watersheds extend for hundreds of miles, the rivers originating in high rainfall mountain areas and continuing through semi-arid and desert areas to the sea. Obviously the forested mountain slopes and seasonal snow fields are an all important part of the watershed for here are the major sources. Problems of extra siltloads and extra salinity coming in at the upper third of the river, for example, have a profound effect on salinization and silting in the lower reaches as they flow through dry areas. In summer, our largest river, the Murray, no longer flows into the sea at its mouth. Integration must involve the entire basin in all its social and economic contexts and not simply the problem of the Murray as seen in the region where it flows through the desert.

Also consistent with this approach is a different way of looking at objectives: at goals to accomplish. We must have objectives of course but we like to phrase them in a somewhat different way. For example, a normal sort of objective would be to direct our efforts at creating a formula that would have general acceptance by scientists and government departments and which would prescribe how to stabilize Australia's downgrading lands and to bring them into a higher level of productivity. This is essentially the strategy that has already been used by our research organizations and several relevant government departments . . . and with little success.

Another kind of objective or range of objectives at least worth trying is to direct our efforts not so much toward accomplishing goals in the usual sense but rather toward initiating trends along multi-faceted fronts: trends that start processes leading to stabilization and improvement, that are designed to keep improving, with built in social and economic mechanisms to ensure that they continue.

Integration

Eventually integration must be an integral part of every aspect of development planning, development implementation and monitoring. The following considers examples of problems of integration at international levels and on a project basis.

On an international basis, in considering the problems of regional social and economic integration in developing countries, South-East Asia may be taken as an example. Here the main institutions concerned are: ministerial meetings, advisory bodies, national secretariats and professional organizations and among these, our main concern is the decision-making process.

Ministerial meetings: Annual meetings of Foreign Ministers of member countries bring together about sixty participants in the organization we know as Association of South East Asian Nations (ASEAN). A standing committee and meeting of national Secretaries-General convenes, although a permanent secretariat is lacking.

Other programmes such as the activities of the Pacific Regional Environment Programme (SACEP) are actively and effectively functioning in increasing communication and co-ordination.

Advisory bodies: ASEAN has gradually built up a network of permanent and ad-hoc committees which do the main work of preparation for the Standing Committee, Secretary-General and national secretariats.

National secretariats and professional organizations: The secretariats function by co-ordinating with other national secretariats and with technical and other committees under their jurisdiction.

Professional organizations: In addition to the above a number of professional organizations have been formed, for example: ASEAN Tours and Travel Association, and Confederation of Chambers of Commerce of ASEAN countries.

The decision-making process is concentrated in ministerial meetings organized by the standing committee meetings.

Other regions have similar efforts at co-ordinating but details vary greatly. For example, institutional ways of bringing about co-ordination on a national basis can be as simple as the procedure used by the Maghreb Group (North-West Africa: Morocco, Algeria and Tunisia) where one person designated by the Minister in each country carries out a co-ordinating function. At the other extreme is an entire department of ASEAN attached to the Ministry of Foreign Affairs in Indonesia. In Latin American countries, co-ordination is more institutional in terms of national commissions, departments or institutes for integration (Sidjanski, D., 1974).

The same author notes that the requirement of unanimity in a group often becomes an obstacle to positive action, creates complicated, often less effective compromises and slows down decision making. This is a good example of a kind of sociological problem which can seriously interfere with the decision-making processes where co-ordination between States is required.

Another way of achieving international co-ordination of efforts or developing truly integrated international programmes is through the creation of international conventions to which signatory States commit themselves. Although there seems little difficulty in securing agreement between nations on conventions to prohibit imports of rare and endangered species, it is a different and much more difficult task to develop mutual agreement between nations on issues with vital economic implications, such as internationally accepted territorial fishing waters. Large river systems flowing through two or more States with desertification problems provide an obvious opportunity for developing some legal mechanism for integrated control of the entire watershed. Without such control, coastal States are certain to have in future, greater siltation, more frequent and larger floods and in some situations, as in the case of the Murray River in South Australia, a cessation of flow in its lower reaches.

One common approach to launching an integrated or co-ordinated approach between countries is to (1) engage a United Nations study team and advisory committee and in the light of their recommendations, (2) specific objectives and priorities are formulated. Once the content and strategy has been defined, (3) appropriate institutions capable of carrying out the programme are selected or established. Such institutions, functioning as a central nucleus supported by several centres of specialized activities, can contribute significantly to development and to the success of regional groupings.

Integration and project development

Integration and relevancy should be an integral part of all phases of the development and execution of a project.

A project can fail for many reasons and during any of its various stages. However, if the project is multi-disciplinary, as most projects in a desertification programme must be, there are four stages rather more basic and critical than others: (a) the identification and formulation of the project, (b) the selection of personnel, particularly the project manager, (c) implementation of the project and (d) monitoring and evaluation. The first and last two stages are emphasized below.

Identifying and formulating projects: In identifying and formulating projects the stage is set for either guaranteeing failure or for giving the project a chance of success. During project formulation is where over-specialization can easily first raise its ugly head. Or, alternatively, the project may be formulated in such a way that integration, between other on-going or proposed projects and within the project itself, becomes imbedded as a natural feature of the project from its start.

Assistance giving organizations can rarely afford the luxury of sending inter-disciplinary teams on a project formulation mission. Yet, here is where an inter-disciplinary perspective is urgently needed. Persons sent on such missions usually have experience with the administrative requirements of the assistance organization and are previously specialized in a particular field.

Recognizing this as a problem is a step forward. I know of three different approaches that have been used with some success. There are certain to be others. The three are: (1) sending a three-man team on a large identification mission, the team consisting of an ecologist, an economist and a sociologist, who consulted closely before the mission in deciding on their approaches, worked on the report jointly during the mission and reported jointly; (2) a project formulation officer from headquarters conducted the mission jointly with an early recruited project manager, both being thoroughly briefed by a wide range of persons knowledgeable about the proposed project area and its people and representing a wide range of interests and experitise; (3) a single officer went on the mission, similarly briefed at headquarters and carrying with him a set of three outlines (or checklists) of the kinds of questions that might be asked by a sociologist, economist or ecologist if they were on the same mission.

Such outlines naturally vary between different kinds of formulation mission but, as an example, one such set of outlines was:

Sociological background

1. Form of government, (a) political climate, (b) stability, (c) number of years under present form of government.

2. Forms of land tenure. (a) state, (b) communal (tribal), (c) individual.

3. Ownership and rights over (renewable) natural resources. (a) legislative framework, (b) special problems, (c) executive action initiated by (communal or individual), (d) administrative framework (and the extent to which a good level of competence is spread throughout the administrative infrastructure).

4. Population and its distribution.

5. Education. Percentage of adults educated to primary, secondary, university levels. Extension and adult education services.

6. Religion. Percentage by major groups, regional differences, influence on social life.

7. Major and minor sources of motivation by region.

8. With the above considerations in mind, list requisite priority problems to be solved whether preceding or alongside the development programme under discussion, desirable (acceptable) limitation of rights to conserve and develop resources, legal compensations or substitutions, etc.

Economic background

What follows assumes that the development will take place on a national scale.

1. The size and level of development of the economy. (a) gross national product (or one of the other national accounts measures), (b) population, (c) gross national product per capita.

2. The structure of the economy. (a) the share of GNP and of the labour force attributable to the agricultural sector, (b) the degree of urbanization, (c) the magnitude and structure of imports and exports.

Item No. 2, in conjunction with 1(c), would give a crude idea of the pattern and level of the national's needs for resources. Appraising the role of the domestic sources of one or more of these resources would require an investigation into: (a) the specific domestic and export markets for the products of the resource, (b) the costs of production domestically relative to world market costs, (c) the social marginal product to be obtained from development of this resource, and its comparison with the social marginal products from alternative uses of the in-puts that would be used in its development.

Ecological background

1. The area defined.
2. Distribution of population.
3. The present pattern of land use. (a) transportation network.
4. An analysis of the extent to which present patterns are satisfactory: (a) present status, (b) recent trends, (c) main problems, (d) prognosis.
5. Alternative patterns for development are suggested based on the above information. (To be compared later with the sociological and economic information gathered).

In considering the formulation of projects it is impossible not to mention the Manual on Project Development, produced by the UN Asian and Pacific Centre for Women and Development (Chaturvedi-Heyn, S., 1979) for it is easily the best manual of its kind that I have seen. It features ways and means of involving the community, even in early preparatory stages and in the design of the project, and community involvement is maintained throughout implementation, monitoring and evaluation. Its simple manner of presentation is deceptive. In my opinion no assistance organization should be without a thorough appreciation of this reference.

Implementation of inter-disciplinary projects

Ways and means must be developed to quickly weld the project personnel into a closely knit team, closely co-ordinating their efforts and closely inter-communicating. This goal is easy to agree with but often difficult to achieve.

Two approaches have in my experience shown enough promise to merit further exploration of their uses and limitations. First, closer attention to project manager and team briefings has in some instances been most effective and second is placing the project on a working plan basis.

In several international organizations it is entirely too common for briefing to be in terms only of administration. Little attention is paid to technical briefing or sociological briefing. A common briefing statement is . . . 'You are the expert and we leave these details up to you.' And still less time is spent in getting closer acquainted with the "expert" to learn more of his personal feelings toward the people of the country he is to assist, his general attitude toward life, the extent to which he always likes to be right, his flexibility and tolerance of others views on a range of subjects, or any other information which may suggest a special type of briefing for the particular "expert" in question.

Second is placing the project on a working plan basis. By this I do not refer to the critical path type of analysis which schedules specific tasks to be accomplished in certain periods throughout the life of the project. This is an excellent way for an officer in headquarters (which insititued the procedure in the first place) to keep in touch with the general progress of the project for administrative purposes. However, as we all know, interdisciplinary projects can proceed precisely on schedule and, in the end be neither inter-disciplinary nor very effective.

An elaboration of such a working plan procedure is perhaps outside the scope of the present paper. Suffice to say that the plans are flexible and details of such plans may be modified as the project proceeds. However, at any point in time, a set of co-ordinated plans has the effect of allowing any government or assistance organization official or project member to appreciate exactly what each member is doing and why (in terms of the project goals, help to the country etc.), how he is proceeding, how the work and the project relates to other development activities or projects, exactly who is responsible for what, how one expert's contribution relates to the rest, how the on-going developments are being monitored, provisions in train for accelerating competence of nationals in the field in question and so on.

This approach seems to facilitate governments being more aware of the value of projects, of headquarters administrators getting a better in-depth appreciation of more than the purely administrative aspects of the project and improves the morale of the project participants.

In project implementation, as in other aspects of project development the above mentioned manual on project development by S. Chaturvedi-Heyn (1979) is well worth consulting.

Monitoring and evaluation

The relevancy of monitoring in a programme to arrest desertification is that it functions as an on-going, project by project, cross-check against present accomplishments and project goals. In other words; to what extent is a project doing what it was designed to do. To function effectively, monitoring should be an integral part of any project.

In terms of project monitoring, Chaturvedi-Heyn (1979) has described monitoring as . . . "a continuing critique of the project's implementation and effectiveness." The same author suggest a monitoring sheet be kept to record if various activities are accomplished within the time planned for them and if an activity becomes behind schedule, to note the basic causes (e.g., resources not available, persons or agencies responsible etc.). Thus the monitoring sheet is suggested as a means of precisely identifying obstacles and operational problems so that a solution can be worked out as soon as possible.

It is obviously useful to make a distinction between keeping track of a project's on-going activities and the extent to which they are on schedule and, on the other hand, the extent to which objectives are being achieved. However, for practical purposes of project integration, it is useful to include in the monitoring process an assessment of the extent to which objectives are being achieved. This makes the assessment of impact an integral part of monitoring. Particularly if monitoring is considered as necessarily being on as broad a base as the integrated project itself (i.e., involving social and economic as well as technical aspects) then the need for monitoring and evaluation to be closely integrated becomes essential.

With the above in mind a useful part of the initial briefing of project managers is to emphasize that, with the most competent people available and with the most sincere efforts being made, every integrated project, as it is being implemented, will encounter obstacles in the form of human problems, economic difficulties, mistakes in planning. The trick in developing effective implementation is not in developing such perfectly planned projects that they will run without a hitch for this hardly happens. The safe and practical approach is to so plan the projects that when (not if) difficulties arise, they can be identified and corrected as soon as possible in line with effectively accomplishing project goals.

These ideas are as important for international programmes as for small projects and are increasingly being used by assistance organizations. For example, the current FAO programme on small farmers development involves local communities in planning exercises and strong self help and grassroots elements are incorporated in the programme. Since evaluation of local projects is done by local people, its future progress seems well worth following.

Meetings and workshops

Just as there have been major advances in chemistry, physics, medicine, plant and animal genetics, ecology or conservation, likewise there have been improved developments regarding the uses and limitations of various types of meetings and other forms of communication designed to accomplish particular purposes. For example, a range of choices now available includes conferences by telephone, committee meetings, workshops, formal conferences, seminars, The Delphi Method and Search Conferences. Uses and limitations of any of these may well be further explored as a means of improving the effectiveness of programmes which intend combating desertification. The latter two are briefly described as they are less well known and the proponents of both seem dedicated to further improve human communication in their different ways.

The Delphi Method: Proponents of this method characterize it as . . . "a method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem." (Linstone, H.A. and Turoff, M., 1975). The Delphi method or process consists of a carefully planned and managed series of written communications between a number of individuals, either responding independantly or representing a larger group. The normal procedure is that: (1) a small "monitor team" designs a questionnaire which is sent to a larger respondent group; (2) after the questionnaire is returned the monitor team summarizes the results and, based on the results, develops a new questionnaire for the respondent group; (3) the respondent group is usually given at least one opportunity to re-evaluate its original answers based upon examination of the group response.

This combination of a polling procedure with a conference procedure thus attempts to shift a significant proportion of the effort needed for individuals to communicate from the larger respondent group to the smaller monitor team and is referred to by the above authors as "conventional Delphi".

A newer form which the same authors refer to as a "Delphi Conference" replaces the monitor team to a large degree by a computer programmed to carry out the compilation of the group results. This eliminates delay in summarizing each round of the Delphi thereby making the "Delphi Conference" almost a written version of a conference telephone call.

Historically, the objective of the first trial of this type of communication was to obtain a consensus of opinion by a group of experts by a series of intensive questionnaires interspersed with controlled feedback of opinion. Since then it has been found useful in various ways of interest to this programme, as:

- "Gathering current and historical data
- Examining the significance of historical events
- Exploring regional planning options
- Planning curriculum development
- Putting together the structure of a model
- Delineating the pros and cons associated with potential policy options
- Developing causal relationship in complex economic or social phenomena
- Distinguishing and clarifying real and perceived human motivations
- Exposing priorities of personal values, social goals etc."

(Linstone, H.A. and Turoff, T.M., 1975).

The method is only outlined above and is difficult to use initially without prior experience in managing this kind of communication system. However, details of the procedures with many examples of its use may be found in the book on the Delphi Method, edited by H.A. Linstone and T.M. Turoff (1975). While the computerized versions of this method are not now appropriate for Third World countries, various modifications of the written version are well worth further consideration on a national or international basis.

The Search Conference: The Search Conference consists of a structured process of participative planning, designed so as to enable groups to clarify their values and purposes, and to translate these into action plans. It is a useful tool for groups or organizations responding to novel challenges, internal or external, and where a wide involvement is thought desirable. The conference requires a minimum of two days and is most effective for groups of between 15 and 35 people.

Search Conferences have proved useful for various purposes, including the setting of national goals by government departments, planning for the future by large industrial organizations, planning action programmes on major conservation issues by a mixture of private and government participants, etc.

Search Conferences, along with participative design workshops (another innovative option not elaborated here) have been used in improving peoples experience in learning and working – in educational work and community affairs. More specifically, successful conferences have been mounted in such diverse areas as strategic planning, management development, organization and work design, participative course and conference design, problem solving conferences, community development activities planning and training programmes, 'futures studies' for major organizations, and social forecasting.

More details of Search Conference procedures can be found by consulting M. Emery (1976), M. Emery and F. Emery (1978) and T.A. Williams (1979). The conferences are usually run by experienced conference managers. At present the main focal points for this approach are the Faculty of Environmental Studies, York University, Toronto, Canada and the Centre for Continuing Education, Australian National University, Canberra, ACT, Australia. An interesting recent development due to the increasing demand for Search Conferences in Australia is that a group of experienced conference managers have recently formally associated into a private consultant group (Futures Search Australia).

In planning organizational, national and international strategies for action, the usefulness of this kind of conference is certainly worth further exploration.

The Delphi Method and Search Conferences from but two examples; there are several more. The point relevant to this discussion is that today there is a much wider selection of types of meeting and other forms of communication than ever before. The management of meetings, small and large, public and private has in fact become almost a specialist subject on its own and in Canada and Australia, there are specialist organizations which may be consulted by private or public organizations as to most appropriate and most effective ways and means of planning, preparing and running meetings to achieve particular ends.

Research

In research as in other generalized tools here discussed there is obviously very much room for improvement. Rather than review desirable research in a balanced way, it may be useful to select a few important gaps for emphasis.

In principle if a problem can easily be identified as large in scale and widely recognized, then such problems should lend themselves to some kind of research to facilitate their solution. In considering action programmes to combat desertification, two kinds of research seem particularly relevant, although neither are commonly considered as subjects for research.

First is the need to develop research on ways and means of improving the effectiveness of inter-disciplinary teams. Some progress has been made on an ad hoc basis in FAO during the 1960's, as mentioned above in discussing project working plans and briefing of personnel, but a great deal remains to be understood and trials of innovative approaches further tested.

The second and by far the most important question which demands increased attention in any programme concerned with downgrading lands is: how can we, on an organizational, national or international basis, improve our ability to profit from experience. There are recent innovations that are showing promise in various ways. For example, the development of Environmental Impact Statements in recent years, the increased interest in monitoring and evaluation, as mentioned above, and the use of case histories as a basis for inter-disciplinary decision making as mentioned below – all are contributions.

But the fact remains that national and international organizations still continue to generate the same kinds of projects and programmes in the same ways that have been demonstrably unsuccessful in the past. Because we are discussing the resource base on which humans depend, surely this problem demands the highest priority in terms of high quality research efforts.

Some other research priorities well worth emphasis are mentioned as a partial answer to the often heard statement that we know all the technical answers. 'If only people would apply them our desertification problems would be solved.' In the interest of accelerating effective actions to combat desertification this statement must be challenged. I suspect that this statement in itself reflects a sociological problem – an attitude of mind held by a particular section of the community (research workers) and which functions as a means of retarding rather than stimulating the gaining of knowledge relevant to solving marginal land problems.

In 1973, I had opportunity to visit two of the top agricultural research stations associated with the drier savannah zones in Africa, one in England; one in French speaking Africa. In that year, within one half-day journey by car from each station, large scale die-offs of domestic cattle and human starvation had taken place, the principal cause being consistent mis-management of the land. This was well known by the research workers, who claimed they had done all they could be publishing their scientific papers which were excellent and read almost exclusively by similar scientists in Europe and North America. In the same areas, I talked with extension workers who were working at the community levels but who could see no particular practical relevance to the work being produced by these research institutions.

With the above in mind and as a slight digression, two guidelines should be considered for what they are worth.

In any situation where human starvation or large-scale stock mortality occurs, or lands are going permanently out of production (or all three), every kind of person from the pastoralists, through the local leaders, extension officers, scientists, teachers and administrators, must take some share of the blame. This admittedly is not the normal approach, which looks for someone other than oneself to blame. However, it is an approach well worth cultivating for it facilitates searching for ways in which concerned persons may improve their contribution in alleviating such problems.

Closely related is the assumption that it is the responsibility of those with the most accurate over-all assessment of the situation to communicate their findings to those with narrow perspectives. And in trying to do so, in my experience it is common for research workers to discover a kind of research which may be more meaningful than the directions they had previously been following.

I suspect that, even technically speaking, new materials, techniques and strategies may be needed to combat desertification. Particularly relevant may be efforts directed toward placing on an objective and easily recognized basis various concepts of conservation, as for example the irreversability of eco-systems once they pass the point of no return. A large set of research needs relate to problem analysis on critical marginal lands and even more attention needs paying to improving and elaborating syndrome approaches, particularly in developing rapid survey techniques for problem analysis (including social and economic aspects of the problems) the determination of critical thresholds, improved techniques for analysis of recent trends etc.

Training

Standard ways of training clearly leave much to be desired in terms of producing people better able to cope with desertification processes. Training needs extend through the various levels of school systems, through university and post graduate training and include extension work and various kinds of adult education as well. To counter over-specialized approaches, considered should be some kind of conversion (or expansion) courses for project managers. In these courses special emphasis may be given to problem analysis and monitoring, both in the broadest sense, and to presenting information on status and trends in ways easily understandable to both politicans and departmental heads. Accelerating experience in interdisciplinary decision making through the use of case histories has already been used with good results in universities and in international organizations (Riney, T., 1972) and this approach is certainly worth encouraging. For participants involved it tremendously accelerates the gaining of experience in decision making within an inter-disciplinary group.

Another type of training which has considerably progressed in recent years is training in man management and in improving abilities to function either as leader or as an integral part of a team. For example, a type of training called Coverdale Training (Roche, S.G., 1967) is proving most effective in enabling managers . . . "to learn firstly, how to learn from experience and, secondly, how to practice (and so acquire) the skills of working with other people." In this way the skills which a person begins to discover during training may be consolidated and developed when he returns to his everyday job. These intensive short courses consists of small groups planning to undertake a task, doing it, and reviewing their own results and suggesting ways by which they can improve in future. . . then, taking another task and repeating the entire procedure again and again as the group proceeds through a series of tasks. Skilled coaches supervise each group and, as such courses normally consist of several groups, they assemble together at least twice a day to compare progress and discuss such principles as may have emerged.

Such courses have proven highly useful in improving the effectiveness of government departments or industrial organizations, for example, and should prove equally effective in improving proposed project managers abilities in successfully managing multi-national and multi-disciplinary projects.

In terms of training appropriate to Third World countries in which desertification is a problem, more relevant approaches to training may be worth trying and several people in different Australian States are exploring alternative or complimentary possibilities. For example, commonly, in any form of rural development, external experts arrive, assess problems and make recommendations based on their own knowledge and experience. A point for concern is that, even if the external advisor is right in his assessment and sound in his recommendations, following this procedure little of the external expertise will be left behind when he leaves. To counter this tendency courses are being prepared whose objective is to accelerate the ability of Third World students to identify for themselves integrated environmental-sociological and economic problems and to themselves devise ways and means of alleviating such problems. The objective would be not so much to equip students with tools of knowledge, as to allow them to accelerate the development of their skills and experience in identifying and in resolving a range of common problems associated with desertification.

With such objectives in mind it follows that future methods of training may differ considerably from standard teaching procedures. For example, one such course now in the planning stage suggests that experience in inter-disciplinary problem analysis would be gained through the use of real case histories, all taken from developing countries. And a large proportion of the time would involve field exercises where the study group would obtain its own material and discuss its own analysis and recommendations with the farmers and graziers concerned.

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PART V

ACTIVITIES OF INTERNATIONAL AND OTHER ORGANIZATIONS

AN ANALYSIS OF RECOMMENDATIONS OF GLOBAL CONFERENCES, OTHER THAN THE UNITED NATIONS CONFERENCE ON DESERTIFICATION, RELEVANT TO DESERTIFICATION*

Preamble

Since the United Nations Conference on the Human Environment met at Stockholm in 1972, our miserable failure to protect some of the more fragile eco-systems from the inroads of the desertification process has not only been given due national and international importance, but has also continued to receive the attention of several organizations of the United Nations system; various global conferences dealing with human needs, such as those on population, food, habitat, water, desertification, science and technology for development planning etc., organized by the United Nations, have followed, in addition to some organized by non-governmental and related United Nations bodies, such as UNEP, FAO, UNESCO, WHO etc.

Desertification has lately been recognized and widely accepted as a self-accelerating and refractory process endangering the quality of land, water, air and other biotic or abiotic natural resources, and thus decelerating the momentum of socio-economic and eco-developmental activities of the affected countries. It is also evident from the recorded documents that, within the decade, many apposite recommendations, resolutions and overtures on integrated plans of action to combat desertification, particularly in the interest of developing countries, have been made by the relevant United Nations organizations and different world conferences summoned by the United Nations.

A brief review and analysis of the more relevant recommendations and resolutions put forth at global conferences, other than the United Nations Conference on Desertification (UNCOD), which have a closer bearing on the programme to combat desertification and may be of immediate interest, are presented here for the benefit of ESCAP countries involved in solving their own desertification problems nationally, transnationally or regionally.

United Nations Conference On The Human Environment, 1972

The recommendations on environmental aspects of natural resources management emphasized the adoption of principles for the development of rural areas comprising not only agricultural lands but also small and medium-sized settlements, for which the co-operation of FAO and other relevant United Nations agencies had been sought primarily in order to share international experience on soil capabilities, degradation, conservation and restoration. Basic research on the soil degradation process in arid areas threatened with desertification was considered to be one of the priorities. Assistance was sought from FAO, UNESCO, WHO and IAEA in applied research on soil and water conservation practices under specific land-use conditions.

While considering the importance of forests and forest management in the development of an environmentally safe eco-system, it was recommended that the MAB programme of UNESCO, in close collaboration with FAO, WHO, ICSU and IUFRO, should promote and co-ordinate research in this field. The active participation of FAO in the transfer and exchange of information on forests and forest management was desired. FAO, UNESCO and several other international agencies were also requested to advise member countries on the specific role of forests in the conservation of soils, watersheds, protection of tourist sites and wildlife, since all of these are known to have a significant impact on biosphere conservation.

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*Prepared by the United Nations Economic and Social Commission for Asia and the Pacific.

As regards the use and management of water resources for developmental purposes, several appropriate United Nations bodies, such as FAO, UNESCO, WHO, WMO, the Department of Economic and Social Affairs of the United Nations Secretariat, IHD and the United Nations Water Resources Development Centre were requested to support government action to assess the environmental effects of existing water uses, including the programme of quality control of water resources as an environmental asset. Morever, it would be the responsibility of the United Nations system to provide technical and financial assistance to governments involved in the various functions of water resources management, should there be any request for such help.

Another recommendation suggested that countries interested in the development and efficient use of remote sensing techniques, especially for resource surveys, should receive encouragement from the specialized agencies of the United Nations when such a request was made.

The support of the United Nations through appropriate agencies for research activities in terrestrial ecology was also envisaged. To promote and facilitate intensive analysis of the structural set-up and functioning of the major eco-systems existing under natural or man-made conditions, it was further recommended that the regional and global network of such current or future research stations/centres and biological reserves be incorporated within the framework of the MAB Programme.

World Population Conference, 1974

Although the World Population Conference of 1974 had little to recommend exclusively on problems of desertification, there were, however, several resolutions and recommendations on interrelated accounts dealing with population, natural resources and environment. Resolutions on conservation of agricultural resources and protection of the environment, particularly in the larger interest of over-populated eco-systems, were adopted.

In the resolutions, due consideration was given to the national demographic trend in relation to the present use of national resources and their impact on environment. In view of the multidimensional problem of preserving the human milieu and available natural resources vis-à-vis the apparently uncontrollable population explosion, especially in many developing countries, it was recommended that the United Nations system should take into account the role of UNEP and provide facilities for central research services that might be utilized by the member States and international community in their endeavour to solve the complex and interdisciplinary problems of population, development, resources and environment at the national and regional level.

The Committee that considered the background document of the Conference on "Population, Resources and Environment" suggested that the World Population Plan of Action might give much greater emphasis than envisaged to the relationship between resources, environment and population, as well as to the mutual relationship between population growth and the demands that this imposed on natural resources and environment. In this context, the two major aspects of issues related to population, i.e. (a) the supply and use of natural resources and (b) the protection of the environment, received the particular attention of the Conference. It was also clearly expressed that to meet the increasing demand for the earth's resources resulting from correlative population and economic growth, it was necessary to provide adequate monitoring facilities and more co-ordinated research for combating undersirable environmental effects. Finally, the committee recommended that for the improvement of the environment, regional and international co-operation should be promoted.

World Food Conference, 1974

The Conference gave emphasis to some of the aspects of desertification processes known to impair land and water capabilities for food production while adopting resolutions and recommendations in this regard. Visualizing soil fertility degradation as the result of inadequate measures for intensifying crop production and grazing, applicable particularly in areas vulnerable to desertification through the processes of water-logging, salinity, alkalinity and wind erosion, the Conference recommended that the governments under such eco-system stress should take timely steps to protect and conserve the soil through the application of appropriate technology and should also try to bring additional lands under cultivation.

FAO was called upon to take up the responsibility of establishing a World Soil Charter which would ultimately serve as the basis for international participation and co-operation in the use and management of the earth's land resources. It was also suggested that UNEP, FAO and UNESCO, in co-operation with WMO and other international bodies and in consultation with the governments concerned, be in a position to undertake an assessment survey of the lands that could be brought under proper cultivation without sacrificing the forests that protect catchment land areas meant for alternate use.

In the course of adopting a resolution on "Scientific water management: irrigation, drainage and flood control", a closer view was taken of the probable interference of desertification hazards. Urgent action to survey exhaustively not only the climatic, hydrological and irrrigational potential but also the hydropower and desert spread was called for and suggested that the responsibility be shared between the governments concerned, FAO, WMO and other interested international agencies. These were also called upon to take all possible measures and apply development techniques to combat the spread of deserts and attempt the reclamation of areas affected by waterlogging, salinity and alkalinity.

To ease the problem of irrigating arid region crop lands with an inadequate water budget, the governments, as well as FAOand WMO, were advised to identify groundwater resources in arid regions and explore the economic feasibility of using non-conventional sources of water, if available in usable quantities. Research and development in the efficient and economic use of water with such techniques as drip and sprinkler irrigation in arid areas was emphasized in the recommendation. For semi-arid and drought-prone areas, the adoption of techniques for the efficient use of available water from groundwater sources was recommended. International institutions and bilateral and multilateral agencies were also called upon to extend substantial assistance to those developing countries which might be able and prepared to take rapid action on such multidimensional projects.

Habitat: United Nations Conference On Human Settlements, 1976

Though there were no categorical references to socio-economic or allied problems pertaining to desertification in the recommendations of the Conference, adequate consideration was given to the environmental aspects of human settlement in the report of the Conference. For example, while recommending that any national economic and social development policy should incorporate an integrated policy for human settlements and environment, the positive role of the environment in national economic and social development was included as was also the relevance of preservation, restoration and improvement of the national and man-made environment to a human settlements policy. As a part of the recommendation on settlement planning in a national context, the necessity for including settlement and environmental planning and development within the periphery of economic and social planning at the national, regional and local levels was suggested. The need for saving land around scattered human settlements from the over-exploitation of national and regional resources as well as for the protection of eco-systems and critical lands was included in the recommendations.

In the recommendations for the increase in usable land, it was suggested that the adoption of appropriate methods for conservation of soils, control of pollution, desertification and salinization, and use of land capability analysis should be taken into consideration in all programmes of land reclamation and preservation. Special attention was drawn to the following relevant actions that might ultimately help maximize usable land:

(a) To fill uneven landscape close to human settlements with solid wastes, while taking sufficient care of the natural environment.

(b) To control soil erosion through reforestation, flood control and flood plain management.

(c) To change cultivation patterns and methods suitably and to check overgrazing.

(d) To halt and reverse desertification and salinization.

(e) To reclaim land areas affected by waterlogging, while disallowing any adverse environmental effects.

(f) To apply new technologies appropriate for flood control, soil conservation and stabilization, and irrigation.

(g) To prevent terrestrial pollution and restore damaged land, and to preserve and protect the environment from natural and man-made hazards.

United Nations Water Conference, 1977

Recognizing the importance of water in the betterment of eco-systems in arid and semi-arid regions, where water and desertification are inseparably interrelated, the Conference deemed it necessary to adopt a separate resolution under the subheading "Role of Water in Combating Desertification" and recorded certain recommendations in that regard. It also appealed to all governments to participate in, contribute to and support the United Nations Conference on Desertification, which was convened later in that year at Nairobi, Kenya.

At the Water Conference it was fully realized that (a) lack of water is one of the main factors that works against the desired development and establishment of settlements in dry areas and causes desertification, leading to environmental degradation, and (b) that water resources development and management are necessary to combat desertification and prevent environmental deterioration. Accordingly, it was recommended that countries affected or likely to be affected by any desertification process should present their problems and programme of action plan for consideration at the subsequent United Nations Conference on Desertification.

Further recommendations called for the following urgent action by countries with serious desertification problems:

(a) A water policy designed to combat desertification should be clearly defined and a comprehensive programme for the development and management of water resources should be formulated. At the same time, the prevailing methods for the assessment of surface and groundwater resources should be intensified and improved.

(b) There should be a programme for the proper use and conservation of surface and groundwater, with adequate incentives for public participation on a self-help basis. The programme should have provisions for the construction of new small dams and wells, as well as the maintenance of existing ones, with appropriate national and international support and assistance.

(c) For specific water-development projects, feasibility studies should be prepared as a part of the overall policy and programme to combat desertification.

(d) Adequate attention should be given to the management and development problems of surface and groundwater resources in arid and semi-arid regions through the establishment of appropriate institutional organizations at the national and regional levels. That was likely to prove helpful in promoting the efficient use of water by developing appropriate technology.

(e) The promotion of research involving various aspects of water resources technology designed to solve the problems of arid and semi-arid regions should be encouraged.

(f) Lastly, international assistance was urged to help equip the member governments affected by desertification problems with adequate financed and technical skills in their efforts to prepare plans and projects for the development and management of water resources to combat desertification.

World Conference On Agrarian Reform And Rural Development, 1979

In its review and analysis of agrarian reform and rural development in the developing countries since the mid-1960s, the Conference briefly touched upon certain environmental problems caused mainly by desertification processes in developing countries, where more than 2,000 million people (or about half the world's population) lived in rural areas, mainly earning their livelihood from agriculture, forestry, fishing and related occupations.

It was admitted that one significant feature of the period under review had been the degradation and depletion of natural resources in the rural areas of developing countries. The severe degradation of agricultural lands and dangerous loss of soil cover in relatively over-populated rural areas were attributed to the increasing extension of agricultural production into marginal areas. The environmental problems created by serious soil erosion, downstream flooding and river siltation, were largely the result of the removal of the forest cover, particularly from sloping lands in the tropics. Similarly, with the unmatched increase in livestock and the probability of overgrazing, the top soil in dry region was damaged because of the extensive loss of its vegetative cover. Such man-made anti-environmental activity often helped the deserts to spread rapidly.

Another important aspect of land degradation, caused by the inefficient irrigation system, was taken into consideration because it was estimated that about half of the available irrigation facilities in developing countries needed improvement. It was stated that the existing system was held responsible not only for the wastage of precious water, but also for the salinization, alkalinization and waterlogging that had collectively reduced the productive potential of millions of hectares of irrigated land and had caused large areas of agricultural land in developing countries to be abandoned.

The depletion of wildlife resources, the degradation of genetic resources and the environmental contamination of food consumed by the rural labour force were mentioned among other environmental problems in rural areas.

United Nations Conference On Science And Technology For Development, 1979

Basically, the Conference was summoned to consider certain current issues related to science and technology, particularly in developing countries. To meet a fast-growing urge for the transfer of technology, institutional management and flow of financial resources in the developing countries, it was deemed necessary first to recommend the strengthening of the science and technology capabilities in the developing countries, the restructuring of the existing pattern of international scientific and technological relations and the improvement of the role of the United Nations system in the field of science and technology; a provision for enhanced financial assistance was also recommended.

Most of the recommendations of the Conference stressed the need and consequent benefit of application of science and technology in developmental activities, rather than their mere suitability and effect in any particular area of human concern. For example, in one of the concluding remarks made by the Working Groups on Science and Technology and the Future, subsequently adopted by the Conference, it was emphasized that all countries should take the responsibility of assessing the trends and consequences of the choice and application of science and technology, with due consideration for the rational use of natural resources and for environmental protection.

Similarly, the recommendation proposing a multi-disciplinary approach in order to solve some of the global human problems related to food, agriculture, natural resources, population, health, education, environment and human settlement, transport and communication, industrialization etc., by the application of appropriate science and technology was nothing more than the customary one, for consideration by the developing countries in particular.

Recommendations For National And Regional Action In The Area Of Desertification Control

The following recommendations are proposed for co-operative national and regional action to combat the vast problem of desertification. They are based on a brief review and analysis of the more relevant recommendations and resolutions made at different conferences convened by the United Nations during 1972-1979, which have a closer bearing on the programme of desertification. These recommendations may be of particular interest to the ESCAP countries involved in solving the problem of desertification nationally, regionally or transnationally. It should be noted that no unique approach can be successful in combating desertification problems; an integrated array of measures suitable to a particular country or groups of country may have to be undertaken to combat desertification and to restore the productivity of areas already affected.

(a) Since the spread of deserts is essentially caused by human activities, it is recommended that an all-out effort be made to create awareness among the people who are affected by the process and to encourage and ensure public participation in desertification control programmes at the national level.

(b) In view of large-scale deforestation in many developing countries of the region and the recent awareness of peoples in developed and developing countries of the importance and role of tropical forests for mankind, it is recommended that effective measures for the protection and management of this valuable resource be supported by all the agencies concerned, at the national, sub-regional and regional levels.

(c) It is recommended that research in terrestrial ecology should be supported by the United Nations and should be incorporated within the framework of MAB. In developing national programmes, special emphasis should be laid on the prevention of soil erosion and sand dune stabilization.

(d) It is recommended that the development and efficient use of remote sensing and other techniques for the monitoring and assessment of the desertification process should be supported by the countries concerned. In this connexion, a "regional desert watch", based on satellite information, should be organized to provide a regional basis for land-use planning and continuous monitoring of the advance of desert conditions.

(e) As part of measures relating to world food production and thus to world hunger, it is recommended that in areas where eco-systems are under stress and vulnerable to desertification, the application of appropriate technology should be seriously considered in order to protect the soil and bring additional lands under cultivation, and to reclaim areas affected by waterlogging, salinity and alkalinity.

(f) As water is a scare and vital resource in arid regions, it is recommended that research and development concerned with the efficient and economic use of available water sources, as well as urgent and comprehensive measures for the conservation and management of water, should be carried out and supported by all concerned agencies, and that the results of such research and development should be disseminated widely throughout the region.

(g) It is recommended that in areas with serious desertification problems or likely to be affected by desertification, environmental planning, including human settlements planning, should constitute an important and integral part of development planning.

(h) In line with the above recommendations, special programmes on desertification control, consisting of component projects in each of the areas affected or likely to be affected, should be formulated and necessary financial allocation should be made in the development budget of the respective countries for implementation of the projects.

IMPLEMENTATION OF THE UNITED NATIONS PLAN OF ACTION TO COMBAT DESERTIFICATION FOR ESCAP REGION*

Introduction

The representative of UNEP has the pleasure to express, on behalf of Dr. Mustafa K. Tolba, Executive Director of UNEP, his thanks and sincere wishes for success to the organizers and participants of this workshop, which is the first of its kind to be convened by the Economic and Social Commission for Asia and the Pacific (ESCAP) in compliance with Recommendation 26 of the UN Plan of Action to Combat Desertification (PACD).

The Plan of Action, within the frame of its recommendations for immediate initial action at the regional level (para. 98.a) has requested that the United Nations Regional Commissions, in co-operation with regional organizations and Governments concerned, should convene regional post-conference technical workshops or seminars to discuss the implementation of the Plan of Action at Regional level and define regional programmes more precisely. This recommendation in this framework of PACD was endorsed by the United Nations General Assembly in December 1977 with resolution 32/172 (para. 6). This Workshop therefore represents a major achievement for realization of one of the initial steps required for immediate implementation of the Plan of Action.

The United Nations Conference on Desertification

The process of land degradation through the activities of man dates back probably to the time he started agricultural practices. However, the worldwide awareness about resulting desertification started only after the Second World War. The problems experienced during the Sudano-Sahelian drought of 1968-1974 served to further attract and focus world attention not only on the relief measures for the concerned population but also on the process of degradation of the environment that led to such accelerated massive destruction of the socio-economic conditions of the countries.

The issue was subject to intensive deliberations at the 29th session of the United Nations General Assembly and a number of resolutions adopted at this session addressed these problems.

While the General Assemply resolutions taken at this session were primarily concerned with the activities of the United Nations System related to the medium- and long-term recovery and rehabilitation of the drought stricken Sahelian countries, others were directed towards the needed actions to control the desertification worldwide. With resolution 3337 (xxix) of 17 December 1974 the General Assembly requested initiation of concerted international action to combat the spread of desertification and decided to convene a United Nations Conference on Desertification (UNCOD). The objectives set for the Conference were:

(a) To raise awareness worldwide about desertification.

(b) To bring together all the scientific and technical knowledge available at that time on the problems and solutions.

(c) To launch and implement in affected countries, the necessary plans and programmes to combat desertification, with the ultimate goal of stopping further degradation by the year 2000.

The United Nations Conference on Desertification was held in Nairobi from 29 August to 9 September 1977. Some 500 delegates from 94 countries and from a number of international and non-governmental organizations participated in the Conference.

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* Prepared by the United Nations Environment Programme, Desertification Branch.

From the ESCAP region nine countries were represented at the Conference. Among them, Afghanistan, Australia, Bangladesh, India, Nepal and Pakistan contributed to the work of the Conference with original papers. In addition seven case studies were prepared by countries from the region. These were: Gascoyn Basin (Australia), Turfan Oasis, Wuchonchao Commune and General Desert Reclamation (China), Turan Project (Iran), Golodnaya Steppe and Turkemania (USSR). Furthermore, two of the six case studies on desertification, commissioned by UNEP for presentation to the Conference, were on the Luni Development Block (India) and Mona Experimental Project (Pakistan).

The United Nations Plan of Action to Combat Desertification

The Conference approved an action plan for combating desertification which, upon adoption by the General Assembly on 19 December, 1977 with resolution 32/172, became the United Nations Plan of Action to Combat Desertification.

The immediate goal of the Plan of Action is to prevent and arrest the advance of desertification and, where possible, to reclaim desertified land for productive use. The ultimate objective is to sustain and promote, within ecological limits, the productivity of arid, semi-arid, sub-humid and other areas vulnerable to desertification in order to improve the quality of life of their inhabitants.

The Plan of Action contains 28 recommendations for action at national, regional and international levels. The specific recommendations of the Plan of Action related to action at national and regional levels include evaluation of desertification and improvement of land management, combination of industrialization and urbanization with development of agriculture in the affected areas, corrective anti-desertification measures, social-economic aspects, insurance schemes against the risk and the effects of drought, strengthening science and technology, and integration of anti-desertification programmes into comprehensive development plans at the national level.

The Plan of Action has also elaborated a set of immediate initial action to be undertaken upon its adoption by the Conference. These are:

(a) At the national level governments to: establish a governmental authority to plan and co-ordinate the activities related to the combat of desertification, assess desertification problems, establish national priorities for action, prepare a national plan, prepare and submit requests for international support and implement the actions to combat desertification in accordance with national plans.

(b) At the regional level, Regional Economic Commissions to: convene regional post-conferences, technical workshops and seminars, conduct inter-regional studies for establishment of regional anti-desertification research and training centres, and organize and co-ordinate implementation of the transnational projects outlined in the feasibility studies conducted for the Conference.

(c) At the international level, UNEP to request the agencies and organizations of the United Nations family to actively associate themselves with the implementation of the Plan of Action, request governments to put forward their needs for international support, undertake the necessary joint programming in order to formulate specific actions, undertake the necessary steps to mobilize financial resources, and arrange and co-ordinate the specific projects and strategies to finance and implement anti-desertification programmes.

The United Nations Environment Programme, with its Governing Council and the Environment Co-ordinating Board, was entrusted with the responsibility of following-up and co-ordinating its implementation and all the agencies of the United Nations System were invited in their respective fields of competence within the Plan of Action, to elaborate methodologies, co-ordinate and support scientific and technological research, facilitate exchange of information, and provide financial and technical support for the implementation of the recommendations outlined in the Plan of Action.

Implementation of the Plan of Action to Combat Desertification

To comply with the responsibilities of UNEP for the follow-up and co-ordination of implementation of the Plan of Action, the following institutional arrangements and complementary activities have been undertaken by UNEP:

(a) A Desertification Branch was established within the structure of UNEP with a small number of staff qualified in the various technical disciplines concerned with desertification. The responsibilities of the Branch, in accordance with the para. 103 of the Plan of Action, includes:

(i) To keep a continuous inventory of all needed programmes and activities dealing with the control and reversal of desertification.

(ii) To prepare or help to arrange preliminary surveys and technico-economic feasibility studies as a basis for formulating projects and programmes.

(iii) To prepare alternative proposals for the mobilization of the necessary capital to finance programmes and projects aimed at combating desertification.

(iv) To monitor the implementation of the Plan of Action.

(v) To record the results of the monitoring of desertification.

(vi) To prepare, compile, edit at six monthly intervals a newsletter, giving information on programmes, results and problems related to the combat against desertification around the world.

(b) In order to assist the desertification-prone Sudano-Sahelian countries in their efforts to combat desertification, UNEP with UNDP approved a joint venture by which the United Nations Sudano-Sahelian Office (UNSO) was given this additional responsibility to act on behalf of UNEP in a total of 19 African countries. To develop the desertification control programmes, UNSO has launched a series of inter-agency planning and programming missions to the countries in the region and initiated preparation of specific anti-desertification projects.

(c) An Inter-Agency Working Group on Desertification (IAWGD) was established to act as the main co-ordinating body for the implementation of the Plan of Action within the United Nations System. The Group is presently considering the preparation of a phased medium-term programme for implementation of both short- and long-term objectives of the Plan of Action by the United Nations Agencies. A draft compendium of on-going activities related to combating desertification of individual UN organizations has also been prepared.

(d) A Consultative Group for Desertification Control (DESCON) was created in response to General Assembly resolution 32/172, to assist the Executive Director of UNEP in mobilizing technical and financial resources for formulation and implementation of projects and programmes within the framework of the Plan of Action. The Consultative Group held meetings in May 1978, March 1980 and August 1981. In the second meeting 27 project proposals prepared by 17 countries with the assistance of Desertification Branch of UNEP and UNSO were considered. 26 out of the 27 projects presented to the Consultative Group have received declarations of financial and technical support from different donor countries, international financing institutions and United Nations Agencies. The third meeting of the Consultative Group held on 26-28 August 1981 considered 12 new project proposals presented by seven African, two West Asian and two South American countries, and one proposal by FAO. The Consultative Group has at present 20 Governments and 8 International institutions as core members, and 9 organizations of the United Nations as co-sponsors. Also a number of governments are represented at its meetings as observers.

(e) A special account to combat desertification was opened by the Secretary General as recommended by the Plan of Action, mainly at the urging of the developing countries. So far only a few governments have confirmed their willingness to contribute to the special account and one has already deposited its pledge of $US 5,000.

(f) In implementation of the General Assembly Resolution 34/184, a study to identify additional ways and means of financing the combat of desertification was carried out through a group of High Level international experts. The study reviewed the various proposals made within and outside of the United Nations System to raise funds for development, and assessed the feasibility and practicability of these proposals in the light of the present political and economic conditions. In addition, the study prepared material on methods for obtaining concessionary loans, raising domestic savings, etc., and prepared financial analysis of demand and supply of funds to combat worldwide desertification. This study was presented by the Secretary General to the General Assembly at its 35th session. The 35th session has now requested UNEP to conduct feasibility studies for the additional means of financing deemed practicable by the Secretary General.

(g) The Desertification Branch has organized preliminary missions to nine of the desertification-prone least developed countries in Africa and Asia, to explore their desertification problems and offer UNEP's assistance in planning for combat of desertification. Two of these countries, Burundi and Tanzania, requested assistance from UNEP. Planning missions arranged by UNEP were sent to these countries to help their respective governments in developing their own national plans of action to combat desertification.

(h) The other activities initiated by the Desertification Branch at the international level include the following:

(i) UNEP/FAO Project on Desertification Assessment and Mapping has been started on the basis of findings of an expert meeting held in May 1979, which recommended a set of indicators to be utilized for the assessment and mapping of desertification at various scales and for different purposes. The project is executed by FAO in co-operation with UNESCO, WMO, and the International Society of Soil Sciences (ISSS). It is expected that the first draft methodology for desertification assessment and mapping will be reviewed and finalized during 1981, after which it will be ready for practical field testing and further evaluation.

(ii) Some components of the FAO Project on Ecological Management of Arid and Simi-Arid Rangelands in Africa and Middle East (EMASAR) and UNESCO's Integrated Project on Arid Lands (MAB-3/IPAL) were supported by UNEP. An evaluation of these two projects was carried out in 1979 and a new phase of IPAL has been initiated in Tunisia.

(iii) UNEP/USSR Project – Combating Desertification Through Integrated Development, which was formulated as a direct response to Recommendation 4 of the Plan of Action, envisages integration of industrialization and urbanization in socio-economic development in arid and semi-arid regions as means to combat desertification. Seven countries affected by desertification have expressed their intention to participate in the project and two United Nations agencies promised their technical assistance.

A training course was organized by the project which was held in the USSR from 18 April to 22 May 1980. Twelve specialists from five countries attended this course. A guideline for formulation of regional integrated development schemes, based on the results of the training course, is about to be finalized by the project. An internatonal symposium on the same subject is scheduled to take place in Tashkent from 5 to 10 October 1981. Also a full-length documentary film is under preparation. In addition, the project is in the process of starting field work to assist the Governments of Peru and Mali in formulation of integrated development schemes for two selected regions in each country.

(iv) International desertification control training courses, organized jointly by UNEP and the Government of USSR for specialists from the developing countries were held in 1978 and 1979. An international meeting convened in Alma-Atta, USSR, in May 1979 to evaluate these courses recommended their establishment on a permanent basis and expansion of the programme by adding range ecology, management and productivity to the present subjects of sand-dune stabilization and problem of salinization in irrigated soils. The courses were conducted in all three subjects in 1980, and were in progress in 1981 (June - October). They will be repeated also in 1982.

(v) An international desertification control training seminar was held in China in August - September 1978 and repeated in September 1981.

(i) The desertification monitoring programmes in South America have been formulated with the assistance provided by the Global Environmental Monitoring System (GEMS) programme of UNEP. A project proposal for Bolivia was presented to the Second Meeting of the Consultative Group in March 1980 while the project proposals for Argentina and Peru have newly been finalized and presented to the third meeting of the Consultative Group in August 1981. Proposals prepared by UNEP are under consideration by the Governments for the countries in South Asia, namely for Iran, Afghanistan, Pakistan and India.

(j) In November 1980 a workshop on the Physics of Desertification was organized by the International Center for Theoretical Physics in Trieste. The workshop, which was co-sponsored by UNEP, addressed major questions related to soil erosion by wind and water, and was attended by about 80 participants, most of them from developing countries.

UNEP's Activities in the ESCAP Region

UNEP, within the frame of its activities directed at the implementation of the Plan of Action, gives high priority to provide assistance to governments for preparation of national action plans to be developed as an integral part of the national development plans, creation or strengthening of national machineries, identification of national priorities, and preparation and implementation of major anti-desertification projects. Consistent with this approach, the Desertification Branch has prepared guidelines for the preparation of a draft of National Plans of Action to Combat Desertification. These guidelines, accompanied by offers of assistance, were submitted to the governments in August 1978 of all desertification-prone countries including the countries in the ESCAP region. No specific action of the use of the guidelines by the governments have been reported to UNEP.

The Desertification Branch, in a follow-up of General Assembly resolution on Least Developed Countries (LDCs), initiated a special programme to provide assistance to the LDCs and organized exploratory missions in 1980 covering Bangladesh and Nepal in Asia. The objective was to impress upon the governments the importance of including a national plan of action to combat desertification as an integral part into their overall national development plans and provide assistance if requested.

As a result, the Government of Bangladesh requested UNEP to provide technical assistance through a team of experts to formulate the outline and prepare a first draft of a national plan of action to combat desertification, to evaluate the needs for further action, to identify priority field of activities and to design key project proposals. The request of the Government of Nepal was for assistance in strengthening the institutional framework of the Government by setting up of an Environmental Management Division to be responsible, among other environmental issues, for the co-ordination of planning and implementation of the anti-desertification activities. Unfortunately, the financial constraints have not permitted UNEP to respond to these requests so far.

The international projects mentioned among other activities of the Desertification Branch in paragraph 12 (h) above have direct relevance to several of the countries in ESCAP region:

(a) India was actively involved in the preparation of UNEP/FAO Project on Desertification Assessment and Mapping. Indian specialists participated in the expert meetings of the project, and helped in the preparation of a draft methodology for assessment and mapping of desertification. Australia, China, Pakistan and the USSR are among the eleven countries selected worldwide to participate in the field testing of the draft methodology to be finalized in the third quarter of this year.

(b) UNEP/FAO project on Ecological Management of Arid and Semi-Arid lands in Africa and the Middle East (EMASAR) have studied the grassland education and training, the results were published in 1977.

(c) India participated in the preparation of the UNEP/USSR project on Combating Desertification Through Integrated Development. Two specialists from Afghanistan attended the training courses organized by the project in April - May 1980 in the USSR. All the countries suffering from desertification in the ESCAP region have been invited to participate in the international symposium to be convened by the project on 5-15 October 1981 in Tashkent, USSR.

(d) UNEP/USSR International Courses on Desertification are open to the specialists from developing countries of the ESCAP region. The courses are in progress at present and will be repeated in 1982.

(e) UNEP/China Desertification Control Training Seminar organized by the Department of Desert Research of the Lanhou Institute of Glaciology, Cryopedology and Desert Research, and held in August - September 1978 was repeated in August - September this year and will most probably continue in the future. This seminar is also open to countries of this region.

UNEP Experience in Assistance to Developing Countries for Preparation of National Plan of Action to Combat Desertification

Before concluding this contribution, it is relevant to give a brief account of UNEP's experience in assisting developing countries with formulation of their national anti-desertification action plans and priority projects prepared within that context. It is believed that this experience will prove to be helpful in assisting the countries in ESCAP region. The missions to Tanzania and Burundi are discussed below.

The major purpose of the missions was to help the concerned governments in preparing a national plan of action to combat desertification as recommended by the United Nations Conference on Desertification (Plan of Action to Combat Desertification: Recommendations 21 and 22). Another important objective was to assist in the establishment of a national machinery within the existing government system to combat desertification. The proposal for the establishment of a national machinery was later incorporated in the draft of the national plan as prepared by UNEP. Two additional objectives for the missions were:

(a) To identify and, whenever feasible, to formulate high priority projects aimed at combating desertification.

(b) To assess the extent of desertification and to suggest high-priority areas for government policy and action.

With a view to identifying the type of expertise needed from UNEP within the framework of the on-going national and international activities, exploratory missions were sent to Burundi and Tanzania in August 1979. In Burundi, the expertise needed to help prepare the national plan was in the fields of regional planning, water resources development, soil conservation, forestry and rural sociology. In Tanzania, the requested multi-disciplinary team was to cover land-use planning, soil conservation and grassland management in arid and semi-arid zones. Suitable consultants, recommended mainly by UN Agencies, were selected and sent in the second half of 1980 to the countries for about three months each. The teams made visits to the desertification-prone areas of the countries and, in close consultation with the counterpart government officials, prepared a draft of the national plan to combat desertification for each country. The draft plans included:

(a) Assessment of desertification problem.

(b) A proposal for national machinery.

(c) Identification of priority areas of action and policies, including research, information, training, etc.

(d) Preparation of proposals for high priority projects.

One priority project from each country was also developed for presentation to the third meeting of the Consultative Group, to be held in August 1981, for funding purposes. These projects were selected to satisfy the following conditions:

(a) Provision of a selected site where the desertification problem was acute and the type of problem tackled was most adequate.

(b) Provision of production component, training component, and some technical assistance.

(c) Provision of some local financing.

UNESCO'S CONTRIBUTION TO RATIONAL LAND DEVELOPMENT IN ARID AND SEMI-ARID ZONES, WITH PARTICULAR EMPHASIS ON THE ACTIVITIES OF MAN AND THE BIOSPHERE (MAB) PROGRAMME*

Nature of the Problem

A number of countries in the ESCAP region, including India and Pakistan, are affected by problems of aridity. The diversity of physical, biological, socio-economic and political situations in these countries gives rise to a great variety of problems. One problem, however, is common to all arid zones: the instability of arid eco-systems and the accompanying potential threat of desertification, provoked in most cases by human intervention in these eco-systems. In practical terms, desertification, which is characterized by the spread of desert conditions beyond desert margins, or by the intensification of soil degradation within arid and semi-arid regions, is accompanied by diminished productivity. In human terms, desertification may be seen as a lowered carrying capacity for livestock, diminishing crop yields, a progressive reduction in real income or in social well-being, and thus a reduction in the number of people that can be supported in an arid region. The activity which triggers the desertification process is very often the only means whereby people concerned earn their living. Hence, stopping this activity cannot be the solution to the problem.

Development of arid and semi-arid lands involves changing the ways in which such lands are used to the benefit of the people occupying them and in such a manner that production from them can be sustained into the foreseeable future. Such changes must take into account the fact that populations in most developing countries with arid and semi-arid climates are likely to continue to grow until the end of the century. A first solution would be to improve existing land management, e.g. through reafforestation or more effective drainage in irrigation systems, or to better inform people through training and demonstration. Lasting solutions must be sought through a case-by-case analysis of all the environmental and socio-economic factors involved, followed by regional planning which emphasizes the reduction of pressure on the land. This can be done by diversifying land-use practices (e.g. complementary grazing and cropping activities, use of new crops) and by creating alternative sources of income not directly based on land exploitation (e.g. cottage handicrafts, tourism).

Objectives of UNESCO's Activities

As also stipulated by the Plan of Action to Combat Desertification, the main objective of UNESCO's activities in this problem area is to reinforce the scientific capacity of countries in the field of ecologically sound land management. The aim is to help these countries to take better advantage of existing knowledge and to undertake new research and training activities so as to ensure that the best use is made of their agricultural, silvicultural and pastoral resources. The full biological productivity of the eco-systems affected by different degradation processes needs to be restored and maintained in the long run.

Network of MAB Field Projects in Arid and Semi-Arid Zones

The promotion of research and training related to rational management of arid and semi-arid lands is one of the priority areas of UNESCO's inter-governmental Programme on Man and the Biosphere (MAB). At its 21st session, UNESCO's General Conference highlighted this fact by launching a MAB-related Major Project of Research, Training and Demonstration Applied to Integrated Management of Arid and Semi-Arid Zones.

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* Prepared by the United Nations Educational, Scientific and Cultural Organization.

Note: Copies of these publications can be obtained either through the official UNESCO publications outlet in every country or directly from UNESCO, 7 Place de Fontenoy, 75700 Paris, France.

The immediate objective of MAB work is to develop nationally-based pilot projects that combine field research, training and demonstration. These projects are conducted on an interdisciplinary basis, with a holistic approach and in association with planners, decision-makers and the populations concerned.

The design of MAB activities in arid and semi-arid zones is based on regional networks of pilot projects. Four inter-linked regional networks are being developed – in Africa south of the Sahara, in North Africa and West Asia, in Latin America, and in Central and Southern Asia. An effort is being made to ensure that these networks cover the different priority problems involved in the development of arid and semi-arid lands (e.g. complementary nature of pastoral and agricultural activities, re-afforestation with drought-resistant trees in order to combat desertification and form renewable energy sources, ecological and socio-economic effects of irrigation, etc.). The networks are also intended to cover the main types of arid eco-systems (hot and cold semi-deserts, dry savannas under tropical climates, steppes and Mediterranean maquis, arid mountain eco-systems), facilitating exchange of information within and between regions.

With the exception of the Central and Southern Asia region, a small nucleus of a network of integrated pilot projects already exists in the other regions mentioned. Governments, MAB National Committees and research and training institutions in the ESCAP region are invited to link their efforts with those of UNESCO and to explore possibilities for developing a network of MAB projects in arid and semi-arid lands in their region. These projects would provide their technical support to the anti-desertification measures in the region, as recommended by the Action Plan to Combat Desertification.

UNESCO

PROGRAMME ON MAN AND THE BIOSPHERE (MAB)

List of recent UNESCO publications concerned with arid and semi-arid lands

A. MAB Technical Notes; relevant titles in this series:

- The Sahel: Ecological Approaches to Land Use. Paris 1975
- Development of Arid and Semi-Arid Lands: Obstacles and Prospects. Paris 1977
- Map of the World Distribution of Arid Lands. Paris 1977
- Environmental Effects of Arid Land Irrigation in Developing Countries. Paris 1978
- Management of Natural Resources in Africa: Traditional Strategies and Modern Decision-Making. Paris 1978
- Trends in Research and in the Application of Science and Technology for Arid Zone Development. Paris 1979

B. Natural Resources Research; relevant titles in this series:

- Review of Research on Salt Affected Soils. Paris 1979.
- Tropical Grazing Land Eco-Systems. A state-of-knowledge report prepared by UNESCO/UNEP/FAO. Paris 1979.
- Case Studies on Desertification. Prepared by UNESCO/UNEP/UNDP. Paris 1980.

WFP ASSISTANCE TO DEVELOPING COUNTRIES

Desertification Control

The World Food Programme

The World Food Programme (WFP) set up jointly by the United Nations and FAO began operations in 1963. Its purposes area:

- To meet emergency food needs and emergency inherent in chronic malnutrition.

- To assist in the implementation of projects for economic and social development, using food as an aid.

Governments in the developing countries often find it difficult, for budgetary reasons, to engage in development programmes which require substantial human participation and other inputs. Furthermore a number of projects which are essential for the countries concerned, like those against desertification, have to be implemented in areas which are the most depressed economically as well as socially. The returns materialize only on a long-term basis and these projects hardly attract the classical type of investment. But, on the other hand, such projects are quite well suited for WFP assistance. Presently the WFP is contributing with aid worth a little over $US 250 million to 53 projects in the field of forest plantation, soil conservation, erosion control etc.

The WFP, a form of complementary assistance

The WFP assistance is a capital input in the form of food given to support national projects, the governments concerned being responsible for the project implementation and for the handling, storage, transportation, distribution and use of the WFP commodities. The governments are also responsible for the technical aspects of the project, while the WFP field officers assist the authorities concerned with the logistic aspects of food aid.

This is an original form of assistance to development projects and can be associated with other types of assistance (such as that from UNDP, World Bank, IFAD) and make it possible to implement programmes which might well remain limited if receiving only the support of the classical types of international assistance. Sometimes, it may appear during the implementation of WFP assisted projects that additional investment studies are needed to obtain better results.

Especially in the least developed countries, however, a number of projects suited for WFP aid cannot even be envisaged, because they lack the technical expertise and funds to meet the cost of non-food inputs such as equipment, tools and supplies. That difficulty can be partly overcome through the approval of appropriate technical assistance projects and by the systematical search of sources to finance the non-food components.

The FAO Technical Co-operation Programme (TCP) and Forestry for Local Community Programme (FLCP) often can provide a useful complement to the WFP assistance.

Desertification control

As mentioned above, the range of activities qualified for WFP aid is quite wide, particularly in the field of erosion control and desertification control. In many poor regions the ecological balance is fragile, and with the prevailing soil and climatic conditions, vegetation survives with difficulty. It is precisely in those regions that pressures from man and cattle on vegetation are more intense and especially the pressure resulting from acute need for fuel. Progressively, in many areas, the vegetation disappears, the delicate water-flow regime degrades and sand dunes encroach upon soils which are poor but still arable.

To check this kind of process, activities are being especially undertaken to stabilize the dunes and to reconstitute the vegetational cover. WFP food assistance to these activities may be given in a variety of ways: either as part payment of the wages of the workers, or as an incentive to land-owners to implement the works on a self-help basis, or even as compensation when the rehabilitation works involve a temporary reduction in returns or the impossibility of using the land for other purposes.

When food rations are provided as part wages, it is often possible to make savings from the overall wages and these can be ploughed back into the project by increasing the labour force or by purchasing the needed equipment and tools. In some countries where regulations prevent the payment of an additional cash element to labourers engaged in heavy work or working in difficult areas, or to skilled workers, food aid may help to solve the problem, as it is an important incentive to attract labourers.

Food aid can also be used as an incentive; for instance, for the establishment of forest plantations on private land or for the maintenance of collective planted areas or for the construction of erosion control structures. The approach for assigning the food rations varies according to the nature of the works and to the results to be attained.

Finally, food aid can serve as a compensation. The works performed on private or collective land may call for the restriction of rights of use or involve a lack of returns. For instance since dune-fixation requires that grazing be banned, the temporary closure of the areas involved might be compensated by food aid, the amount of food provided being calculated according to the loss incurred.

Therefore, for many types of works, and particularly those to prevent desertification, WFP may provide an adaptable form of assistance where flexibility results from the possibility of using any of the three above mentioned systems. It is a new form of assistance which can also be adopted to complement the more classical types of financial aid.

Study Case No. 1 – Dune Afforestation in Socialist Republic of Vietnam (WFP project 2396)

The region and its problems

The provinces of Binh Tri Thien and Quang Nam-Da Nang Stretch along the coast for more than 300 km between the 18th and 16th parallels.

Going inland from the sea they consist successively of:

- An almost continuous coastal belt of fairly unstable sandy dunes.
- A fairly narrow strip of farmland, which widens out at the deltas of the small coastal rivers to form basins, sometimes quite large.
- An area of low hills with steep slopes, already deforested many years ago.
- Finally, the foothills and the mountains of the Chaîne Annamitique, where there are still a few forests.

The population of these provinces is relatively large and reaches an average density of 215 inhabitants/sq. km.; but it varies according to the area, and is concentrated mainly in the coastal strip, in the deltas, in some internal valleys and in the main towns.

As in the other parts of the country, agriculture remains the principal economic activity, but it suffers from adverse climatic conditions: frequent dry winds blowing from north-west and very violent winds coming from south-east, associated with torrential rains and devastating typhoons. Furthermore, the cultivated lands near the coast are threatened by dunes displaced by the south-east winds and advancing at an estimated rate ranging from 5 to 30 m per year.

These two provinces were the scene of successive battles throughout the war. They were particularly affected by bombardments and spraying with defoliants. The result was a very important degradation both of the natural cover and of the man-made plantations which had been established for the dune fixation. This damage has been compounded by the consequences not only of excessive and uncontrolled exploitation of the forest resources to fulfil local needs for fuel and timber, but also of the traditional shifting cultivation.

The degradation has led to:

- a pronounced erosion
- an impoverishment of the soil
- very irregular flow in the water courses and a reduction of water availability for human needs as well as for agricultural purposes
- an invasion of cultivated fields by dunes
- a shortage of wood for domestic uses

Aim of the project

The project is intended to ensure the protection of soils, cultivation and infrastructures through the fixation of the dunes and the reforestation of the denuded hills. The implementation of the project will also permit wood and fuel-wood production and the creation of employment for a large number of people who were displaced by the war.

45,000 ha. will be either planted or replanted (20,000 in the province of Binh Tri Thien and 25,000 in that of Quang Nam-Da Nang). Simultaneously a range of activities will be undertaken: clearance of mines; opening of roads, tracks and fire breaks; seed collection and nursery maintenance. It is anticipated that over 15,000 workers will participate in the project and will benefit over the duration of the project from 11.5 million family rations (a family ration being calculated on 5 individuals each receiving 400 grams of wheat flour, 20 grams of oil, 10 grams of canned meat or fish each day).

Implementation

When the project interim evaluation was carried out, approximately half of the works planned had been implemented. With regard to the forest plantations, the main species adopted were *Casuarina equisetifolia* on coastal sand and *Pinus merkusii, Pinus kesiya* and *Eucalyptus* sp. in the highlands.

Rainfall data indicate the heaviness of the rains during the humid season and the long duration of the dry season. Plantation is, therefore, difficult to undertake on the instable coastal sands, considering the high temperatures and the length of the dry season. This explains the selection of Casuarina as it gives excellent results under these conditions; it fixes the dunes and it constitutes wind breaks. The usual plantation density is 5,000 seedlings/ha. Soil preparation is sometimes done by mechanical ploughing but generally is done by hand. The rate of survival is around 75 per cent; failures result mainly from adverse climatic conditions but also from the lack of experience of the workers. A limited number of Eucalyptus were planted in the highlands. The preference was given to *Pinus merkusii* and *Pinus kesiya* however. The average density is 2,500 seedlings/ha. The seedlings are produced in polythelene bags. The rate of survival amounts to approximately 70 per cent.

Trials are being conducted to introduce other species as well (*Pinus caribaea, P. oocarpa, P. elliottii, Gmelina arborea, Leucaena glauca, Eucalyptus* sp.)

The plantations were protected from man (smuggling of fuelwood), fire (fire breaks), cattle (establishment of transit trails) and insects (a long and difficult process due to lack of means).

The seedlings were delivered by nurseries managed under the project.

Conclusions

Given the food shortage prevailing in Vietnam, WFP assistance represents a substantial input for alleviating the traditional food deficit which exists in the two provinces concerned. It permits workers and their families to benefit from food rations which are close to the national norms. In addition, WFP aid facilitates the implementation of works already undertaken, protecting cultivated fields located between the dunes and the hills area which have made it possible to put under cultivation portions of the stabilized dunes and finally have allowed the obtaining of a more regular water flow.

Reforestation of coastal dunes cannot be expected to produce much wood per hectare (mostly for fuel in any case), the essential purpose being protection. The hills, on the other hand, should play an important role in supplying wood for sawing and pulp.

Finally, food aid has permitted the short term creation of seasonal and permanent jobs as well as the training of skilled workers. In the long run, a labour force specialized in afforestation works will be constituted which will be of great help for the implementation of eventual forestry development programmes.

Study Case No. 2: Dune Fixation in Southern Morocco (WFP project 2526)

The region and its problems

In the pre-saharian provinces of Errachidia and Ouarzazate, the encroachment of continental dunes under wind action threaten the palm groves, the villages and communications, and endanger costly investments such as the dams and irrigation systems financed by the Government of Morocco.

Taking into account the high costs of large scale control of desertification as well as the social implications for a population profoundly attached to its land and to its traditional methods of agriculture, the government has selected the two valleys of Oued Ziz and Draa which are particularly endangered.

Studies have been conducted under FAO-TCP and UNDP/FAO projects, to determine the movements of the sand and to establish a programme of action. The sand dune creep results in a threefold consequence:

- The reduction of arable land.
- The disappearance of villages and of infrastructures.
- The creation of desert conditions and the impossibility of access to the watertable thus jeopardizing the government's efforts to improve the living standard of the population.

Aims of the projects:

- To stop the arrival of additional sand through the establishment of a system of palisades.
- To fix the foredune system with vegetation.
- To plant trees on all land to be protected.

As a consequence the losses in agricultural production resulting from sand accumulation should be reduced, and agricultural output should even be increased in areas where the work will be combined with irrigation work.

A social problem arises since the project is to be implemented mostly on privately or collectively owned lands which means that the people will have to stop making use of those lands for a certain time or even for ever and this obviously is not well accepted.

Achievements

120 km of palisades will be established during the project duration. To avoid the palisades being covered by sand, they will be regularly raised until the dunes reach a fairly stable profile.

45 hectares of dunes with a stable profile will be covered with a checkerboard system of palisades; 100 ha of land will be planted with trees, the seedlings being raised in nurseries also managed with a WFP contribution. The land under treatment will have to be fully protected for a certain length of time. On the other hand, once cultivated land now covered by sand is still to some extent used as free range pasture. The stabilization of all these areas and their full protection need an adequate compensation which will incite their users to participate actively in the work programme. Therefore, food aid will help in meeting three requirements:

- Temporary compensation of a premanent loss of agricultural production.
- Compensation of the loss incurred by the non-use of range land.
- Incentive to the owners/users to participate in the dune fixation programme.

With regard to the last target it should be noted that WFP assistance will also serve as an encouragement in the protection and maintenance of the plantation (especially watering during the first few years). The population will receive food rations for all the works which will be organized and implemented collectively.

Conclusion

With project 2526, too, WFP constitutes an important element in the improvement of the diet of the local population and permits, through the delivery of food rations, workers and their dependents to implement large-scale activities which are essential for the survival of the region. The works will be undertaken under the supervision of the Moroccan Forestry Service which has the means needed and the know-how for their implementaion. The present achievements have made it possible to halt a number of dunes which were threatening villages; and the WFP contribution plays an effective role in getting the collaboration of the local people who, in spite of the acute danger which threatens them, are traditionally diffident of the forestry service. One may hope that this very direct way of assistance will help the people thoroughly to take charge of the question of desertification control, which is of such immediate concern to them.

STATEMENT BY WMO

The eighth Congress of WMO, adopted a Special Programme of activities entitled "Agriculture and Desertification Programme". Under this programme concerted efforts are being made to assist Member Countries of WMO to advise on the better application of meteorological, climatological and hydrological knowledge to the development of agriculture and to the fight against desertification. Desertification is of direct interest to four of the eight technical Commissions of WMO. The Commission for Agricultural Meteorology has a special working group on Agro-meteorological Aspects of Land Management in Arid and Semi-arid areas with special reference to Desertification.

The Monex Monsoon Experiment and TCSU has direct bearing on the aridity problems of ESCAP Region.

In the international field, WMO, is co-operating with UNEP, FAO and UNESCO on Desertification problems.

STATEMENT BY SOUTH ASIA CO-OPERATIVE ENVIRONMENT PROGRAMME

The representative of SACEP stated that, having recognized desertification as an important environmental problem in the region, his organization had included it among the already identified projects, which also included activities dealing with environmental education, environmental legislation, environmental management, social forestry and environmental impact assessment. He stated that SACEP was willing to extend its fullest co-operation to ESCAP in the identification and implementation of projects, as well as in exchanging views in the field of the environment, including attempts to combat desertification.

ANNEXES

ANNEX I

List of Documents

(A) Country Reports

1. Afghanistan
2. Australia
3. Bangladesh
4. India
5. Indonesia
6. Iran
7. Nepal
8. Pakistan
9. Philippines
10. Thailand
11. USSR

(B) Documents From Various Agencies

1. ESCAP : Sociological Constraints and Innovations in Combating Desertification: by Thane Riney
2. ESCAP : Assessment and Monitoring of Desertification processes: by C. Torres
3. FAO : Technology of Soil and Water Conservation in Arid and Semi-arid Areas
4. UNEP : Implementation of the United Nations Plan of Action to Combat Desertification for ESCAP Region
5. UNESCO : Contribution to rational land development in arid and semi-arid zones, with particular emphasis on the activities of the Man and the Biosphere.
6. WFP : Desertification Control – WFP Assistance to Developing Countries
7. WMO : Technology on Meteorological and Hydrological Aspects of the Combat Against Desertification
8. IRAN : Summary of Geologic Phenomenas and Effects in Farming Environmental Particularities of Iranian Plateau: by A. Motamed
9. ESCAP : Status of the Implementation of the Plan of Action to Combat Desertification in the ESCAP Region: An Overview

   I. Summary of the country reports

   II. Analysis and synthesis of the country reports
10. ESCAP : An Analysis of Recommendations of Global Conferences, other than the United Nations Conference on Desertification Relevant to Desertification

    Note by the secretariat

ANNEX II
List of Participants

	Bangladesh
Mr. Sheikh Abid Ali	Director, Bangladesh Water Development Board, Motijheel Commercial Area, Dhaka 2.
Mr. Shamsul Alam	Assistant Technological Adviser, Science and Technology Division, Cabinet Secretariat, F-4 Pubali Building, Circuit House, Dhaka 2.
	France
Mr. Boudet Gabriel	Agricultural Range Management Officer, IEMVT, Animal Husbandry and Veterinary Research Institute, 10 R.P. CURIE, 94704 MAISONS-ALFORT Cedex.
	India
Dr. O.P. Gautam	Director-General, Indian Council of Agricultural Research, Krishi Bhawan, New Delhi.
Dr. N.S. Randhawa	Deputy Director-General, (Soils), Indian Council of Agricultural Research, Krishi Bhawan, New Delhi.
Dr. H.S. Mann	Director, Central Arid Zone Research Institute, Jodhpur.
Shri R. Rangachari	Member, Indo-Bangladesh Joint Rivers Commission, Ministry of Irrigation, New Delhi 1; Sinchai Mantralaya, opp. Secretariat.
Dr. Dilip K. Biswas	Director, Department of Environment, Technology Bhawan, New Mehrauli Road New Delhi 110029.

Shri D.S. Upadhyay	Meteorologist, Hydrology Section, Mausam Bhawan, Lodi Road, New Delhi-3.
Dr. M.N. Qureshy	Director (Earth Sciences), Department of Science and Technology, Technology Bhawan, New Mehrauli Road, New Delhi.
Dr. C.M. Mathur	Director, Desert Afforestation and Pasture Development, Central Arid Zone Research Institute, Jodhpur.
	Indonesia
Mr. Toto Hendroto	Directorate of City and Regional Planning, Directorate-General Cipta Karya, Ministry of Public Works, Jakarta.
Mr. Achmad Indrawan Sulaeman	Directorate of City and Regional Planning, Directoriate-General Cipta Karya, Ministry of Public Works, Jakarta.
	Iran
Mr. Morad-Ali Ardeshiri	Expert in Watershed Management, Bureau of Soil Conservation and Watershed Management, Forestry and Range Management Organization, Ministry of Agriculture, Tehran.
Mr. Mohammadhosein Gharavi Isfahani	Senior Expert in Watershed Management, Bureau of Soil Conservation, Forestry and Range Management Organization, Ministry of Agriculture, Tehran.
Mr. Hossein-Ali Alaeddini	Expert in Control of Chemical Production, Mulching Bureau, Forestry and Range Management Organization, Tehran.
Mr. A. Motamed	Professor, Iran Desert Research Centre, Tehran University of Tehran, Tehran 14.
	Nepal
Mr. J.P. Gorkhali	Under-Secretary, National Planning Commission, Kathmadu.

Mr. P.M. Baisyat	Chief, Bagmati Watershed Project, 237/1 Mahraj Gunj, Kathmandu.

The Philippines

Mr. Ed. B. Pantastico	Deputy Director-General, The Philippines Council for Agriculture Resources Research (PCARR, Los Banos, Laguna Province.

Thailand

Mr. Dusit Sinthavalai	Senior Agronomist and Chief of Statistical Planning and Analysis Branch, Soil and Water Conservation and Land Management Division, Department of Land Development, Ministry of Agriculture and Co-operatives, Bangkok.
Mr. Suphavit Piamphongsant	Director, Environmental Policy and Planning Division, Office of the National Environment Board, Rama VI Road, Bangkok 10400.

Union of Soviet Socialist Republics

Prof. A.G. Babaev	Director, Desert Institute, Turkmen.
Dr. V.G. Cheremisinov	Assistant Agricultural Attaché, USSR Embassy, Chanakyapuri, New Delhi 110057.

United Nations Bodies

World Food Programme (WFP) Mr. Trevor Page	Deputy Representative, WFP, 55 Lodi Estate, New Delhi-3.

Specialised Agencies

Press Foundation of Asia (PFA) Mr. Prakash Chandra	Chief, DEPTHNEWS Bureau, F-25 Press Enclave, Saket Malviyanagar, New Delhi-110017.

South Asia Co-operative Environment Programme (SACEP)	
Mr. D.A. Lokupothagamage	Assistant General Manager, Water Resources Board, 259/4 Hospital Road, Kiribathgoda-Kalaniya, Sri Lanka.
	Secretariat
Mr. K.F. Jalal	Chief, Environmental Co-ordinating Unit, Office of the Executive Secretary
Mr. A.H.V. Sarma	Consultant, Environmental Co-ordinating Unit, Office of the Executive Secretary
Mr. Supochana Narongkhananukul	Administrative Assistant, Environmental Co-ordinating Unit, Office of the Executive Secretary.
	Consultants
Mr. Brian Spooner (USA)	Department of Anthropology, University of Pennsylvania, Philadelphia PA 19104, (Expert)
Mr. S.H. Rasul (India)	Professor, Department of Geology, Aligarh University, Aligarh, U.P. (Expert)
Mr. Thane Riney (Australia)	Centre for Continuing Education, Australian National University, Canberra (Expert)
Mr. P.Y. Revilliaon (France)	Head of Remote Sensing Division, BDPA Bureau for Development of Agricultural Production, 202, rue de la Croix-Nivert 75738 Paris, Cedex-15.

ANNEX III

UNITED NATIONS NATIONS UNIES

Economic and Social Commission for Asia and the Pacific
Environmental Co-ordinating Unit
Bangkok, Thailand

Presents

"DESERTIFICATION – A PEOPLE'S WAR"

On the occasion of
UN/ESCAP Regional Technical Workshop on the Implementation
of the Plan of Action to Combat Desertification, 20-23 October 1981
Jodhpur, Rajasthan,
India

Credit Title:

"A PEOPLE'S WAR"

A UN/ESCAP Presentation

Script/Director/Production: Mr. G. D. Bhattacharya

Creative assistance

Voice ....

Appearance ....

Technical assistance

Music ....

Choreography ....

Light ....

Sound ....

Effects ....

Make-up ....

Costume ....

Set ....

Stage Management ....

Acknowledgements

Science Adviser	:	Professor S.H. Rasul Head of the Department of Geology, AMU
Background Music	:	.... Collection, Delhi
Graphics, pictures, slides	:	Department of Geology, AMU, Aligarh
Set-cartoons	:	Fine Arts Club, AMU, Aligarh

∗ Realization ∗
Aligarh Muslim University Drama Club
Aligarh, UP, India

∗ ∗ ∗ ∗ ∗ ∗ ∗

The United Nations and its various agencies have been pursuing, for more than three decades, a number of activities directed towards the improvement of the quality of life of the people, but, most of it being confined in documents (such as Plan of Action) which are not binding on any government, they did not have much effect on the people for whom those activities and plans were designed.

In order to overcome such a problem, most major UN efforts are supported by an 'Information Component' – rich film libraries, well-equipped audio-visual sections with distribution channels throughout the world. But, with a retinue of sophisticated accessories, it also has its own limitations; it lacks the personal touch that is inherent in stage performances. It may not also be an effective approach to attract the interest and involvement of people who are directly affected by the problem. Then why not exploit this complementary if not different approach? The playwright, experienced as he is in all the media, was haunted by the question: "Is it possible to translate the entire paper work alias UN activities in terms of theatre – that, too, minus conventional storyline, artistic abstraction, and/or scientific distortion?"

With the above background in view and considering the significance of human factors in desertification control, this modest programme titled "A People's War" is being presented to the participants of the Workshop and the people of Jodhpur. While the original working script in English will be presented to the international participants of the Workshop, its Hindi version will be presented to the local people of Jodhpur who are living in the areas affected by desertification process.

The play depicts the lifestyle of people living in areas affected by desertification, their moments of joy and sorrow, their problems and approach to dealing with these problems. It opens up in gay atmosphere which soon evaporates at the advent of adverse conditions which threaten the existence of otherwise simple and happy people. The serious happenings lead to the probe by scientists and experts into the processes of desertification in the next sequence. Thereafter, world's attention is drawn towards the problem and the 'Plan of Action to Combat Desertification' (PACD) is drawn up. Next sequence, captioned 'The People's War", has a dual meaning – on the one hand, it identifies various remedial measures to be adopted to counter desertification; on the other, it envisages active participation of the people on all fronts of the war. And, then, as in epics and dramas, the denouement is arrived at in sequence No. 5 – not with the so called high optimism, but with a profound pledge to continue the people's war to a finish. Their war-cry; "Victims today, victorious tomorrow"!

"A People's War" is neither fiction nor fictitious, nor a dream, not even a utopia; it is unadulterated reality 'happening' behind the proscenium. Based on UN documents on desertification, especially PACD, it is, strictly speaking, a scientific approach – dramatized, where research and field work are embellished with theatrical ingredients, bear on basic facts of life juxtaposed through a play.

"A People's War", the "performing thesis on desertification" is, to be precise, a documentary play mounted with the ritualistic technique of 'Total Theatre' – where no movement is considered undramatic, no prop deemed untouchable, where life, nothing but life 'exists' on the stage.

The documentary play "A People's War" is just an illustration of how a scientific programme can be metamorphosised into a visual art and the high and dry message transferred comfortably to the spectators who tend to become instantly aware of the problem closing in on them.

The same materials, retold through a well-delineated story, with a central and more than one sub-plot, may be transformed into a full-length play where facts of life surcharged with 'high' emotions compel the spectators to get out of themselves and be one with the dramatic characters, their sufferings and struggle. It is equally true of a full-length feature film which has the capability of overlapping space time continuum.

DESERTIFICATION AND MASS CONTACT

by

Mr. G. D. Bhattacharya

Desertification may be introduced as a new terminology in the English dictionary, but not as a new phenomenon in the earth's history. It has been at work at Sumer, Babylon, Harappa, at the Cedar forests of Lebanon and elsewhere. Plato, the Greek genius, has left for us a vivid description of the horrors of desertification, both natural and man-made, in his lament on Atticca in 'Critias'. In 'King Oedipus' by Sophocles of the same classical Greece, we have this stark description of Thebes:

"Death in the fruitful flowering of her soil;
Death in the pastures, death in the womb of woman;
And pestilence; a fiery demon gripping the city;"

It is an old story. The novelty lies in the recent appraisal of desertification as a global human problem which is corroding, like cancer, the arid, semi-arid regions and extending into adjacent sub-humid regions.

The recognition of the severity of the menace resulted in the development of a Plan of Action to Combat Desertification (PACD) in 1977 under the leadership of the United Nations Environment Programme (UNEP). It is now for the countries and all the relevant United Nations' organizations including ESCAP to implement PACD and control desertification process in the Asia and the Pacific region. PACD was subsequently endorsed by the General Assembly and aims at controlling desertification process by the year 2000 A.D.

One of the main themes of the Plan asserts 'in educating the people and the affected communities to an awareness of the problem, and instituting training programmes in collaboration with in ternational organization', and 'in applying existing knowledge, not only to stop the physical processes of desertification, but to educate people in minimizing the harm done to the fragile eco-systems of drylands by existing economic and social activities.'

PACE also 'recommended that public participation be made an integral element of the prevention and combating of desertification and thus account be taken of the needs, wisdom and aspirations of the people.' This recommendation implies national action 'to increase general awareness of the problem of desertification and a better scientific understanding of new and old technology through education, group discussions and exhibitions, etc. In rural schools, training centres and extension services, as well as in appropriate institutes and universities, programmes for teaching the proper use of land and other natural resources should be initiated and strengthened to ensure the participation of sectors of the population (through) expansion and strengthening of the role of community organizations . . . to achieve mutual understanding and trust by stimulating public participation, making arrangements for joint discussions and using the mass media. . . . . . .'.

It should be the duty and purpose of every government to implement, along with others, the recommendation regarding public awareness and involvement – as it is only with their co-operation and collective efforts that any combat programme can be successfully implemented.

A review of the situation as depicted in the documentation to the Workshop generally reveals that the progress in respect of the above is not so satisfactory. There are indeed many instances of people's participation, collective struggle, discussions, seminars, publications, press releases, use of media, etc. Heartening though they are, they do not seem to be successful in ensuring people's participation in many cases although they have met with success in some countries. The efforts, therefore, need to be further strengthened particularly by coupling them with development of well-co-ordinated field programmes at the local level. Since the problems of desertification are manifold and complex, the model and technique of solving them are equally manifold and complex. And, generation of public awareness and people's involvement in desertification control measures is one of the basic and primary moves. To be precise, it is a challenge to the planners and representatives of mass media in the countries, and it is high time that a sound infrastructure vis-a-vis public relations was developed and action-oriented programmes implemented without further delay.

To start with the classroom, educational network should focus on the environmental problems and on complimentarities between combat against desertification programme and other developmental programmes. The existing education systems should be reoriented through the introduction of special courses, and training programmes at all levels. While adult education and other social services may be inducted in the process, instructional projects in primary and secondary schools should be started immediately. Simultaneously, top priority should be given to the publication of text books, journals bulletins, newsletters and such other environment literature – both serious and popular, both for adults and children.

As for the utilization of mass media, a people-oriented programme should be adopted with due regard to the local talents, resources and environment. The newspapers and journals, national and local, should respond to the PACD recommendations and try to keep the people, educated elites as well as common man, alert to the situation, help form public opinion through regular insertions and quotes from UN findings and other sources. Equally, radio should broadcast, besides talks, features, plays, musicals, etc., captions and slogans.

TV can go further beyond by directly involving the people through interviews, question hour, instructional programmes, lecture demonstrations and so on. Film, more powerful as it is, should add to its repertoire, not only documentaries, shorts and cartoons, but also full-length features. With proper incentives provided by the authorities, film makers may be induced to serve the people while they need it.

In this age of space communications, mass contact is becoming easier job. Mobile audio-visual vans can penetrate deep into the remote rural parts of a country. More advanced countries in the developing world may go in for more sophisticated communication systems.

Printing and electronics are too young compared to the stage, which has a long history of several thousand years. It is an inherent part of human tradition and culture and is nearer to the heart of the people. It can be put up any time, anywhere, empty handed, without dependence on any of the modern technological gadgets. Besides, with umpteen variations, local versions, styles and schools, it has endless possibilities, and if properly and imaginatively used, it will act as the major medium of mass contact and mass communication.

The documentary play "A People's War", due to be staged here in Jodhpur, is just an illustration of how a science thesis can be metamorphosised into a visual art.

Another, equally effective, less costly, and job-oriented visual activity is 'Interpretative Service' where country-guides, while interpretating an art object or an archaeological site or a museum or sanctuary, can add a few sentences on desertification. Signs, symbols, charts, graphics, etc, can be used for open and spot display; labels, slogans, etc. may be attested on boxes, packets or projected on the picture house screens with slides. Exhibition of pictures and photographs and also of props and objects just mentioned above will add strength to the effort. Even road shows, circus, fairs, street plays can be utilized for the same purpose.

In addition to all these, the proposed infrastructure can also help in activating community services, initiating pilot area projects, indoor/outdoor workshops, and other public relations services. Revival of ancient rituals, such as, 'tree worship', in new forms will be an encouraging and engaging activity of the community centres.

Last but not least, 'Environment Club' is another viable medium with branches all over the country, engaged in serious and channellized activities, the 'Club' can inspire a movement at par with the Wild Life Association, Nature Conservation Association, Chipko and film society movements.

All these activities should be closely and neatly interlinked. This necessitates establishment of a central institute which will act as the base for environmental clubs. The Centre will undertake research and development exploring appropriate techniques of mass communications suited to the country and culture, preparing well-knit work programmes, catering expertises, training manpower, that is, public relations officials. It will also undertake positive exploitation of mass media and implementation of the mass contact programme.

In keeping pace with the transnational and international anti-desertification activities, the infrastructure should include in its work agenda monitoring, transfer of expertise, exchange of technologies and programmes beyond its national periphery.

The basic principles guiding the Plan of Action emphasize that all actions shall be consistent with the provision of the Charter of the United Nations. It is, therefore, appropriate that all the national mass contact activities in this region should be linked with the Environmental Co-ordinating Unit, Economic and Social Commission for Asia and the Pacific as the main stream of the regional activity on desertification.

The mass communication programme under 'Belgrade Charter' as approved at the International Workshop proposes to develop a world population which has the awareness, knowledge, skill, attitude, motivation, commitment and dedication to work individually and collectively towards the solution of the existing problems and prevention of new ones.

It is the primary duty of communication systems everywhere to accept the challenge and help build up a new genre of world population in order to win over a brave new world, and transform the combat against desertification into a massive people's war.

ANNEX IV

GENERAL ASSESSMENT OF PROGRESS IN THE IMPLEMENTATION OF THE PLAN OF ACTION TO COMBAT DESERTIFICATION: 1977-1984

DESERTIFICATION QUESTIONNAIRE

UNITED NATIONS ENVIRONMENT PROGRAMME

Nairobi, July 1982

Na. 82 - 5626

INTRODUCTORY NOTE

The Desertification Questionnaire is in three parts. Part I seeks information on the main characteristics of the drylands in national territories; Part II asks for details on the status and trend of desertification; and Part III aims to obtain data on activities to control desertification since the United Nations Conference on Desertification in 1977.

In several of the tables, information is sought for the different climatic zones within the drylands: hyper-arid, arid, semi-arid and sub-humid. These are as defined and mapped by UNESCO in the Map of the World Distribution of Arid Regions, published in 1979 as MAB Technical Note No. 7.

To provide a picture of changes or trends in the status of desertification, some of the tables seek information, for the two years 1980 and 1970. 1980 was chosen as the latest year for which many of the statistics would be available, and 1970 as a possible census year, before the Plan of Action to Combat Desertification was initiated, to give a basis for comparison over a decade. Where statistics are not available for those years, figures for other years may be substituted to serve the purpose.

A few tables ask for information on production, costs, losses etc. in money terms. For comparability, these should wherever possible be given in United States dollar equivalents at 1980 rates.

Where lack of statistics makes it impossible to respond in the quantitative terms indicated by the Questionnaire, it would be appreciated if estimates could be provided, even if in a more general form. Space is left on the reverse of the tables for additional information or for general comments on the topics treated.

Part I. Background Information on the Drylands

Contents:

Table 1 A: Population of the drylands – 1980 and 1970*

(Other appropriate years may be substituted for the decadal census years proposed. Where census statistics are not available, estimates for the climatic zones and for the drylands as a whole would be welcomed. Additional information or more general statements would be welcomed and should be entered overleaf.)

	Climate zone	Hyper-arid	Arid	Semi-arid	Sub-humid	Total drylands	Whole country
1980*	Total						
	Urban						
	Rural: Mainly crop-based						
	Mainly livestock-based of which: Mainly nomadic						
	Mainly sedentary						
1970*	Total						
	Urban						
	Rural: Mainly crop-based						
	Mainly livestock-based of which: Mainly nomadic						
	Mainly sedentary						

* Or other appropriate census years.

Table 1 B: Mortality statistics for the drylands – 1980 and 1970*

(Where census statistics are not available, estimates of differences between rural and urban populations, and between those of the drylands and the humid sector of the country would be welcomed, with information on the basis of estimates where appropriate. Where information on population trends is available over a longer period than the decade indicated, this would be welcomed and should be entered overleaf.)

Mortality		Annual rate of population growth %	Birth rate (No. of births per 1000)	Infant mortality %	Life expectancy (years)
1980*	Rural drylands				
	Urban drylands				
	Average drylands				
	Average for whole country				
1970*	Rural drylands				
	Urban drylands				
	Average drylands				
	Average for whole country				

* Or other appropriate census years.

Table 1 C: Population Movements: 1970-1980

Population migrations within the drylands, between the dryland and humid sectors, within and beyond the country, and between the rural and urban sectors have always been significant for the economy of the drylands. Table 1 C seeks information on annual movements, averaged over the decade 1970-1980 or an equivalent or longer period, against which such changes might be identified. Where census data are lacking estimates would be welcomed, and where response on a whole-country basis is not possible, information on particular regions would be valuable and should be entered overleaf.

Indicate which kinds of population movements exist, estimate the number of people involved, and give a brief description of the phenomenon including the areas over which these movements occur:

☐ Nomadic movements within rangelands:
average annual number of population moving ____________________

Describe:

☐ Migrations between rangelands and croplands:
average annual number of population moving ____________________

Describe:

☐ Movement to towns and large population centres:
average annual number of population moving within drylands/beyond drylands ________ / ________

Describe:

☐ Exodus to the humid sector of the country:
average annual number of population moving ____________________

Temporary/permanent ________ / ________

Describe:

☐ Migration out of the country:
average annual number of population moving ____________________

Temporary/permanent ____________________

Describe:

Table 2: Land use and land cover in the drylands - 1980

(Where statistics are not available, estimates for individual climatic zones or for the drylands as a whole would be welcomed. Additional information and general comments may be entered overleaf.)

Climatic zone	Rainfed croplands		Irrigated lands total area (Thousand of hectares)	Rangelands		Forests and woodlands		Other (Thousands of hectares)
	Total area (Thousands of hectares)	Area cropped annually (Thousands of hectares)		Mainly sedentary use (Thousands of km^2)	Mainly Nomadic use (Thousands of km^2)	Plantations (Thousands of hectares)	Natural (Thousands of hectares)	
Hyper-arid								
Arid								
Semi-arid								
Sub-humid								
Whole drylands								
Whole country								

Table 3 A: Crop production from the drylands: 1980 and 1970

(Where precise information is unavailable, estimates would be welcomed. Where information is not available for climatic zones, an estimate of the value of rainfed crop production for the drylands as a whole would be welcomed.)

		Irrigated lands	Plantations and woodlands	Rainfed croplands				
				Arid	Semi-arid	Sub-humid	Total drylands	Whole country
1980	Total value of production (million of $US)							
	Three main crops in order of value							
1970	Total value of production (millions of $US)							
	Three main crops in order of value							

Table 3 B: Livestock production from the drylands: 1980 and 1970*

(Where statistics are not available for climatic zones, estimates of livestock populations and of the value of livestock products for the drylands as a whole would be welcomed.)

		Hyper-arid		Arid		Semi-arid		Sub-humid		Total dryland		Whole country	
		Population (Thousands)	Annual value of marketed product (Thousands of $US)	Population (Thousands)	Annual value of marketed product (Thousands of $US)	Population (Thousands)	Annual value of marketed product (Thousands of $US)	Population (Thousands)	Annual value of marketed product (Thousands of $US	Population (Thousands)	Annual value of marketed product (Thousands of $US)	Population (Thousands)	Annual value of marketed product (Thousands of $US)
1980*	Cattle												
	Sheep												
	Goats												
	Camels												
	Others												
	Total												
1970*	Cattle												
	Sheep												
	Goats												
	Camels												
	Others												
	Total												

* Or other appropriate years.

Part II. Status and Trend of Desertification

Contents:

Table 4: Extent of desertification by major land-use types, 1980 and 1970

Climatic zone	Degree of Desertification[a]	1970						1980					
		Irrigated lands		Rainfed croplands		Rangelands		Irrigated lands		Rainfed croplands		Rangelands	
		Area affected (Thousands hectares)	Population (b) in area affected (Thousands)	Area affected (Thousands of km^2)	Population (b) in area affected (Thousands)	Area affected (Thousands of km^2)	Population (1) in area affected (Thousands)	Area affected (Thousands of hectares)	Population (1) in area affected (Thousands)	Area affected (Thousands of km^2)	Population (1) in area affected (Thousands)	Area affected (Thousands of km^2)	Population (1) (in area affected (Thousands)
Hyper-arid	Moderate												
	Severe												
	Very severe												
Arid	Moderate												
	Severe												
	Very severe												
	Moderate												
Semi-arid	Severe												
	Very severe												
Sub-humid	Moderate												
	Severe												
	Very severe												
Whole Drylands	Moderate												
	Severe												
	Very severe												

[a] As defined in the Attachment.

(b) If population figures or estimates are not available for separate areas subject to moderate, severe and very severe desertification, then please give the population for each climatic zone, or for the drylands as a whole.

Attachment to Table 4: Extent of desertification by major land-use types: 1970 and 1980

(Estimates are welcomed where more precise data are lacking, and estimated trends over the last decade may be used to supplement the latest available evidence where data is not available for two base years. Other census years may be substituted for 1980 and 1970 where appropriate. Where data are lacking for climatic zones, please give estimates for the drylands as a whole. Please use space overleaf for additional or more general comments.)

The following guidelines should be used in categorizing the degree of desertification.

Irrigated lands	Rainfed croplands	Rangelands
Moderate (M)	*Moderate (M)*	*Moderate (M)*
Widespread but moderate problems of salinization etc. subject to treatment through land improvement and better management, with minor works; loss of production up to 25 % of that envisaged in the original plan for the scheme.	Widespread and locally severe erosion, requiring some reclamation and widespread conservation measures supported by improvement management; loss of production up to 25 % of earlier output.	Significant reduction in cover and deterioration in composition of pastures; locally severely eroded; would respond to management supported by improvements and conservation measures. Loss of carrying capacity up to 25 % of earlier carrying capacity.
Severe (S)	*Severe (S)*	*Severe (S)*
Major desertification problems widespread; some major works required, supported by land improvement; loss of production 25-50 % of that envisaged in the original plan for the scheme.	Severely eroded and locally nonproductive; requiring widespread reclamation and conservation measures supported by soil improvement and improved management; loss of production 25-50 % of earlier output	Very significant reduction in perennial vegetation cover and widespread deterioration in composition of pastures; widespread severe erosion; requiring major improvements. Loss of carrying capacity 25-50 % of earlier carrying capacity.
Very severe (VS)	*Very severe (VS)*	*Very severe (VS)*
Large areas non-productive and requiring major improvement works; loss of production above 50 % of that envisaged in the original plan for the scheme.	Large areas barren and uncultivable, with very severe erosion and requiring major reclamation, locally on an uneconomic scale; elsewhere requiring significant reclamation and conservation measures; loss of production over 50 % of earlier output.	Extensively denuded of perennial shrubs and grasses and subject to widespread very severe accelerated erosion; large areas irreclaimable economically. Loss of carrying capacity over 50 % of earlier carrying capacity.

Table 5: Desertification of major irrigation projects or areas 1970-1980

Project/area and location	Area irrigated (Thousands of hectares)	Sources of water	Three main crops	Population (Thousands)	Desertification				Changes over the last decade or since establishment if after 1970
					Status	Processes	Causes	Consequences	

Attachment to Table 5: Desertification of major irrigation projects or areas: 1970-1980

(Please provide information for as many major projects or areas as possible, including areas of dry-season irrigation within rainfed croplands. Where precise data are lacking, estimates or general descriptions are welcomed. Additional information or more general comments may be entered overleaf. Status of Desertification should be entered as very serious (VS), serious (S) or moderate (M) with reference to the criteria listed in the attachment to Table 4. Sources of irrigation water and processes, causes and consequences of desertification should be identified by number from the attached list and entered in order of estimated importance, with degree of importance indicated as follows: very important 24**; important 24* and secondary 24. General comments are invited on any changes in the status of desertification of irrigated lands over the last decade.

Sources of irrigation water:

11 Floodwaters
12 Diversion from perennial rivers
13 Large dams and other man-made storages
14 Shallow wells
15 Interception galleries (qanats)
16 Deep wells or artesian supplies
17 Other (specify) . . . .
18 . . . .

Desertification processes:

21 Waterlogging
22 Secondary salinization or alkanization
23 Sand encroachment
24 Other (specify) . . . .
25 . . . .
26 . . . .

Causes of desertification related to water-supplies:

31 Diminished river flows
32 Siltation of storages
33 Declining groundwater yields
34 Over-pumping
35 Salinization of irrigation water
36 Over-extension of irrigated area
37 Competition from non-irrigation use
38 Other (specify) . . . .
39 . . . .

Related to irrigation practices:

41 Poor land preparation
42 Over-irrigation
43 Inadequate leaching
44 Unsuitable crops/tillage methods
45 Use of saline water
46 Rising regional water tables
47 Other (specify) . . . .
48 . . . .
49 . . . .

Related to operations and maintenance:

51 Unsuitable soils or terrain
52 Inadequate land drainage
53 Seepage from channels and canals
54 Poor on-farm maintenance
55 Operational and administrative shortcomings
56 Inappropriate land subdivision
57 Other (specify) . . . .
58 . . . .

Other causes of desertification:

61 . . . .
62 . . . .
63 . . . .
64 . . . .
65 . . . .

Consequences of desertification:

71 Abandonment of irrigable lands
72 Diminished frequency of cropping
73 Diminished yields
74 Switch to less valuable, tolerant crops
75 Health problems
76 Out-migration of farmers
77 Other (specify) . . . .
78 . . . .
79 . . . .

Table 6: Desertification of rainfed croplands: 1970-1980

(Where information is not available for individual climatic zones, estimates for whole drylands are welcomed. Additional information or general comments may be entered overleaf. Indicate which processes, causes and consequences of desertification apply by entering the following number code in the appropriate column and row: 1 for very important; 2 for important; and 3 for secondary, and by circling the most important in each division of the table. Columns have been left blank for entering additional processes, causes and consequences. Desertification of areas of dry-season irrigation in rainfed crop-lands is treated in Table 5.)

Climatic zone		Desertification																					Comment on changes in desertification status of rainfed croplands over the last decade or other appropriate years
		Processes							Causes								Consequences						
	Decline in soil fertility	Accelerated water erosion	Salinization/alkalization of soils	Crusting of soils	Accelerated wind erosion	Sand drifting/burial			Prolonged drought	Cropping beyond safe climatic limits	Cropping of unsuitable soils or terrain	Unsuitable cropping practices	Shortened fallows/clearing cycles	Increased population pressure			Lowered yields	Abandonment of croplands	Rural out-migration				
Arid																							
Semi-arid																							
Sub-humid																							
Whole drylands																							

Table 7: Desertification of rangelands: 1970-1980*

(Where information is not available for individual climatic zones, estimates for whole drylands are welcomed. Additional information or general comments may be entered overleaf. Indicate which processes causes and consequences of desertification apply by entering the following number code in the appropriate column and row. 1 for very important; 2 for important; and 3 for secondary, and by circling the most important in each division of the table. Columns have been left blank for entering additional processes, causes and consequences.)

Climatic zone	DESERTIFICATION																								Comments on changes in status of rangelands over past decade
	Processes							Causes									Consequences								
	Deterioration in composition of pastures	Diminished vegetation cover	Accelerated water erosion	Accelerated wind erosion/sand-drifting	Severe denudation around water-points			Increased numbers of livestock	Restrictions on grazing area	Restriction on movements of livestock	Inadequate natural watering points	Insufficient man-made watering points	Introduction of permanent waters into seasonal pastures	Fuelwood gathering	Excessive/inappropriate burning		Abandonment of rangelands	Change in patterns of seasonal grazing	Decline in livestock numbers	Change in herd composition	Human out-migration	Change in settlement patterns			
Hyper-arid																									
Arid																									
Semi-arid																									
Sub-humid																									
Whole Drylands																									

* Or other appropriate years.

Table 8: Degradation of forests, woodlands and plantations in the drylands: 1970-1980

(Where precise information is unavailable, estimates are welcomed, either for particular climatic zones or for the drylands as a whole. Where there is evidence of longer-term changes in the extent of forests etc., please comment overleaf with an indication of sources where possible. Where information is not available on a whole-country basis, evidence on significant regions is also welcomed. Indicate the relative importance of listed causes and consequences of deforestation by entering a number code in the appropriate space as follows: 1 for very important; 2 for important; and 3 for secondary and by circling the most important in each division of the table. Please specify other causes or consequences of desertification in the blank columns. Other appropriate years may be substituted for 1980 and 1970.)

Climatic Zone	Extent of natural forest or woodland in 1980 (km^2)	% Change ± over past decade	Extent of plantations in 1980 (km^2)	% Change ± over past decade	Causes of deforestation								Consequences of deforestation (specify)						
					Clearing for grazing/over browsing	Clearing for cropping	Felling for commercial timber	Fuelwood production (domestic and industrial)	Charcoal production	Settlements, communications, mining, etc.	Excessive/inappropriate burning								
Arid and hyper-arid																			
Semi-arid																			
Sub-humid																			
Whole drylands																			

Table 9 A: Deterioration of major surface water storages in the drylands

(Where precise information is unavailable, estimates are welcomed. Additional and more general information may be entered overleaf.)

Storage and and type of construction	Location	Year constructed	Original capacity ($m^3 \times 10^3$)	Expected service life (years)		Major water uses (specify in order of importance)	Causes of deterioration (specify)	Consequences of deterioration (specify)
				When constructed	Latest estimate			

Table 9 B: Deterioration of major aquifers or groundwater basins in the drylands

(List the main aquifers or groundwater basins. Where precise data are unavailable, estimates are welcomed. Additional information and general comments are also welcomed, and should be entered overleaf.)

Name, location and geological formation	Extent (thousands of km^2)	Type*	Range of depth	Water quality	Main uses (in order of importance)	Nature of deterioration	Consequences of deterioration (specify)

* Please specify whether confined (C), unconfined (U), or artesian (A).

Table 10: Impacts of major droughts since 1970

(This information is sought as a background to changes in desertification and progress in combating desertification. Please use one column for each major drought, making additional copies of the table as needed. Where precise information is lacking, general statements on the incidence and impacts of major droughts are welcomed and should be entered overleaf.)

Period of drought 19 . . . . to			
Extent and location of area affected (thousands of km^2)			
Drought rainfall as % of mean			
Impact on rainfed crop-lands: – % failure by area			
– % reduction in crops by value			
Impact on Livestock production: Estimated no. in area at drought onset by type of animal (thousands)			
Estimated losses due to drought by type of animal (thousands)			
Estimated no. moved out of area by type of animal (thousands)			
Impacts on human popu-lations: Estimated no. in area at drought onset (thousands)			
Estimated deaths due to drought			
Estimated out-migration (thousands)			
Estimated costs of drought, including famine relief (thousands of $US)			
Other impacts: (Please specify)			

Part III. Measures To Combat Desertification

Contents:

Table 11: Projects forming part of measures to combat desertification

Subtitle[a]

(Please supply information for the major projects listed under this category. Where precise information is unavailable, estimates would be welcomed. Additional information on the projects listed, and more general statements on the type of activity covered in this table, may be entered overleaf. This is a standard table to cover many types of activities as listed in the attachment and respondents are asked to make multiple photocopies before using.)

Project	Location and extent thousand of km^2)	Objectives	Agent	Duration actual or planned (y)	Estimated cost (thousands of $US) and source of funds	Actions involved (Please specify)	Results to date[b] (Please specify)	Population benefiting (thousands)

[a] Please insert appropriate subtitle below from those listed in the attached to table 11.

[b] Please emphasize impacts on desertification.

Attachment to Table 11: Projects forming part of measures to combat desertification

Information is sought on the following types of projects recommended under the Plan of Action to Combat Desertification. Please use the standard forms attached and enter the appropriate subtitle. Please include projects planned, formulated and initiated since 1977, and also older projects that have continued to operate since that date. Respondents are asked to identify projects submitted through the Consultative Group for Desertification Control.

A. Assessment, mapping and monitoring of desertification.

B. Establishment or strengthening of meteorological, climatological and hydrological recording networks, remote-sensing and mapping facilities, and other means of monitoring desertification in the drylands.

C. Establishment and strengthening of systems for monitoring the human condition in the drylands, with appropriate indicators in relation to population, human and environmental health, nutrition, settlements, education, socio-cultural patterns, land-use and production.

D. Reclamation or conservation projects for desertification control in rangelands, rainfed croplands and other non-irrigated lands, including stabilization of sand dunes.

E. Measures to conserve the indigenous flora and fauna of the drylands, and to improve wildlife management.

F. Reclamation or conservation projects for desertification control in irrigated lands.

G. Development and improvement of water resources and supplies in drylands.

H. Afforestation, plantation and forest improvement projects in the drylands, including shelter belts.

I. Reclamation and conservation of non-agricultural lands subject to desertification, including settlements, industrial, mining and construction sites, and communications.

J. Development of new or alternative energy sources in the drylands, including fuelwood plantations, coal, petroleum or natural gas reserves, schemes to introduce the use of biogas, solar or geothermal energy, improved technology in energy use, etc.

K. Land-use planning, ecological management and related projects in the drylands.

L. Integrated rural development schemes for the drylands.

M. Improvements in rural and urban settlements in the drylands, and schemes for the sedentarization of nomads.

N. Provision of adequate domestic water supplies, sanitation, health and family planning services in the drylands.

O. Provision of adequate educational, social and cultural facilities and information services in the drylands.

P. Measures to minimize the risks and effects of droughts and the provision of insurance and other schemes for drought relief and rehabilitation.

Table 12: Projects aimed at creating additional employment and income in the drylands (for example mining, industrial developments (including agro-industries), new or supplemental agricultural developments etc.)

(Please use one column for each project, and include projects formulated, planned or initiated since 1977 as well as earlier projects that have continued to operate since that date. Where precise information is unavailable, estimates are welcomed. Additional information on the projects listed, or more general comments on the type of activity covered in this table, may be entered overleaf.)

Project			
Location and area covered (thousands of km^2) Population benefiting (thousands)			
Objectives			
Agent			
Estimated proposed investment (thousands of $US and source of funds)			
Duration, actual or planned (give dates)			
Projected annual income to be generated (thousands of $US)			
Projected number of jobs created			
Actions involved (specify)			
Results to date (emphasize impacts on desertification)			

Table 13: Establishment or strengthening of research institutions in the field of desertification control (1977 to date)

(Please use one column for each institution concerned with desertification issues. Additional information may be entered overleaf.)

Institution and address		
Director		
Controlling body and source of funds		
Year of establishment/ strengthening		
Number of professional staff		
Number of support staff		
Sites of field/experimentation stations		
List main research projects relevant to desertification control, with dates		
List main research findings relevant to desertification control, with details of reports published since 1977		

Table 14: Establishment or strengthening of teaching and training institutions in the field of desertification control (1977 to date)

(Please use one column for each relevant institution. Additional information may be entered overleaf.)

Institution and address		
Director		
Controlling body and sources of funds		
Year of establishment/ strengthening		
Tertiary, technical or vocational		
Number of professional staff		
Number of students		
List courses of study including length of course, awards, and annual number of graduates		

Table 15: Establishment or strengthening of information centres and mass-media services for consciousness-raising on desertification issues (1977 to date)

(Under types of audience addressed, please give estimated numbers in the following categories: policy-makers, planners and managers; technicians, teachers and trainers; general public. Additional information may be entered overleaf.)

Name of centre or service	Location	Date established	Areas served (km^2)	Population served	Types of audience addressed	Means of dissemination and channels of information employed

Table 16: Other actions to combat desertification (1977 to date)

(Please list any other measures taken to combat desertification from 1977 onwards, including actions initiated previously which have continued since that date. These should include any measures which are considered relevant to desertification control, including legislative actions. Please make additional photocopies of the table as required before using.)

Action taken	Duration (give years)	Location and extent of area affected (thousands of km^2)	Population in area (thousands)	Costs (thousands of $US) and source of funds	Results to date*

* Please emphasize impacts on desertification.

Table 17: Evaluation by Governments of progress in and constraints on implementing measures to combat desertification (1977 to date)

(Estimates are welcomed where precise data are lacking. Additional and more general information under this topic may be entered overleaf.)

Organization responsible for co-ordinating measures to combat desertification and address		
List the main threats of desertification as perceived in 1977 (in order of importance)		
List what are considered to be the main achievements in combating desertification since 1977 (in order of importance)		
Estimate the costs of measures to combat desertification since 1977 (Thousands of $US)		
List the main sources of funds		
Rank what are considered to be the main constraints to progress in combating desertification by numbering the boxes in order of importance. Use the blank boxes to enter additional constraints.	☐ Environmental (including climate)	☐ Inadequate assessment of desertification problems
	☐ Inadequacies in the formulation of projects and programmes	☐ Inadequate monitoring and reassessment of desertification
	☐ Scientific and technological limitations	☐ Lack of trained manpower
	☐ Organizational constraints	☐ Financial limitations
	☐ Lack of public awareness and participation	☐
	☐	☐
List what are perceived to be the continuing threats of desertification (in order of importance)		