MEDITERRANEAN ACTION PLAN
MED POL

UNITED NATIONS ENVIRONMENT PROGRAMME

PROMOTION OF SOIL PROTECTION AS AN ESSENTIAL COMPONENT OF ENVIRONMENTAL PROTECTION IN MEDITERRANEAN COASTAL ZONES

PROMOTION DE LA PROTECTION DES SOLS COMME ELEMENT ESSENTIAL DE LA PROTECTION DE L'ENVIRONNEMENT DANS LES ZONES COTIERES MEDITERRANEENNES

PRESENTATION OF DOCUMENTS PRODUCED IN THE PERIOD OF THE PRIORITY ACTION (1985-87)

REPRESENTATION DES DOCUMENTS REDIGES AU COURS DE LA PERIODE DE L'ACTION PRIORITAIRE (1985-87)

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This volume is the sixteenth issue of the Mediterranean Action Plan Technical Report Series.

This Series will collect and disseminate selected scientific reports obtained through the implementation of the various MAP components: Pollution Monitoring and Research Programme (MED POL), Blue Plan, Priority Actions Programme, Specially Protected Areas and Regional Oil Combating Centre.

Ce volume constitue le seisième numéro de la série des Rapports techniques du Plan d'action pour la Méditerranée.

Cette série permettra de rassembler et de diffuser certains des rapports scientifiques établis dans le cadre de la mise en oeuvre des diverses composantes du PAM: Programme de surveillance continue et de recherche en matière de pollution (MED POL), Plan Bleu, Programme d'actions prioritaires, Aires spécialement protégées et Centre régional de lutte contre la pollution par les hydrocarbures.

PREFACE

The United Nations Environment Programme (UNEP) convened an intergovernmental Meeting on the Protection of the Mediterranean (Barcelona, 28 January - 4 February 1975), which was attended by representatives of 16 states bordering on the Mediterranean Sea. The meeting discussed the various measures necessary for the prevention and control of pollution of the Mediterranean Sea, and concluded by adopting an Action Plan consisting of three substantive components:

- Integrated planning of the development and management of the resources of the Mediterranean Basin (management component);

- Co-ordinated programme for research, monitoring and exchange of information and assessment of the state of pollution and of protection measures (assessment component);

- Framework convention and related protocols with their technical annexes for the protection of the Mediterranean environment (legal component).

All components of the Action Plan are interdependent and provide a framework for comprehensive action to promote both the protection and the continued development of the Mediterranean ecoregion. No component is an end in itself. The Action Plan is intended to assist the Mediterranean Governments in formulating their national policies related to the continuous development and protection of the Mediterranean area and to improve their ability to identify various options for alternative patterns of development and to make choices and appropriate allocations of resources.

The Priority Actions Programme (PAP), a component of the integrated programme of the Mediterranean Action Plan (MAP) promotes the exchange of experience in the fields of integrated planning and management of resources in the Mediterranean coastal areas.

The starting point of the PAP activities is the awareness that the protection and sound management of the environment can only be implemented by means of a rational development which translates into an optimum exploitation of natural resources. The notion itself of environment in a broader sense and especially in the Mediterranean context is at the same time the most precious resource of the Area.

Within the framework of the definition of the PAP activities, the representatives of the Mediterranean Governments, the Contracting Parties of the Barcelona Convention, have established the following priorities for the PAP:

- human settlements
- water resources management
- soil protection against erosion
- tourism
- aquaculture
- renewable sources of energy

In the abovementioned areas, the following activities are being completed:

- directories of Mediterranean institutions and experts
- water resources management
- integrated planning and management of Mediterranean coastal zones
- protection and rehabilitation of historic settlements
- land-use planning in earthquake zones
- soil protection against erosion
- solid and liquid waste management, collection and disposal
- development of tourism harmonised with the environment
- aquaculture
- renewable sources of energy
- environmental impact assessment
- balance between the hinterland and the coastal zones

The United Nations Agencies, many international organisations and almost all Mediterranean countries take active part in all these activities.

This volume, which is the 16th in the Mediterranean Action Plan Technical Reports Series, contains selected documents concerning the Priority Action entitled "Promotion of soil protection as an essential component of environmental protection in Mediterranean coastal zones" covering its first phase.

PREFACE

Le Programme des Nations Unies pour l'environnement (PNUE) a convoqué une réunion intergouvernementale sur la protection de la Méditerranée (Barcelone, 28 janvier - 4 février 1975) à laquelle ont pris part des représentants de 16 Etats riverains de la mer Méditerranée. La réunion a examiné les diverses mesures nécessaires à la prévention et à la lutte antipollution en mer Méditerranée, et elle s'est conclue sur l'adoption d'un Plan d'action comportant trois éléments fondamentaux:

- Planification intégrée du développement et de la gestion des ressources du bassin méditerranéen (élément "gestion");

- Programme coordonné de surveillance continue, de recherche, d'échange de renseignements et d'évaluation de l'état de la pollution et des mesures de protection (élément "évaluation");

- Convention cadre et protocoles y relatifs avec leurs annexes techniques pour la protection du milieu méditerranéen (élément juridique).

Tous les éléments du Plan d'action étaient interdépendants et fournissaient le cadre d'une action d'ensemble en vue de promouvoir tant la protection que le développement continu de l'écorégion méditerranéenne. Aucun élément ne constituait une fin à lui seul. Le Plan d'action était destiné à aider les gouvernements méditerranéens à formuler leurs politiques nationales en matière de développement continu et de protection de zone de la Méditerranée et à accroître leur faculté d'identifier les diverses options s'offrant pour les schémas de développement, d'arrêter leurs choix et d'y affecter les ressources appropriées.

Le Programme d'Actions Prioritaires (PAP), partie du plan intégré du Plan d'Action pour la Méditerranée (PAM), a pour but de promouvoir des échanges d'expériences dans les domaines de la planification intégrée et de la gestion des ressources des zones côtières méditerranéennes.

Le point de départ des activités du PAP est la connaissance que la protection et la promotion de l'environnement ne peuvent être réalisées que grâce à un développement raisonné qui se traduit par une exploitation optimale des ressources naturelles. La notion même de l'environnement, conçue dans un sens plus large, et tout particulièrement dans des conditions méditerranéennes, constitue en même temps la plus précieuse ressource de la Région.

Dans la phase de la définition des activités du PAP, les représentants des Gouvernements meditérranéens, Parties Contractantes de la Convention de Barcelone, ont précisé les domaines prioritaires du PAP, notamment:

- établissements humains
- gestion des ressources en eau
- protection des sols contre l'érosion
- tourisme
- aquaculture
- sources d'énergie renouvelables

Dans les limites des domaines précités, les actions suivantes sont en voie d'achèvement:

- répertoires des institutions et experts méditerranéens
- gestion des ressources en eau
- planification intégrée et gestion des zones côtières méditerranéennes
- protection et réhabilitation des sites historiques
- aménagement du territoire dans les zones sismiques
- protection des sols contre l'érosion
- gestion, collecte et élimination des déchets solides et liquides
- développement du tourisme en harmonie avec l'environnement
- aquaculture
- sources d'énergie renouvelables
- évaluation des impacts sur l'environnement
- interrelation côte - arrière-pays

A toutes les actions prennent part les organismes des N.U. et de nombreuses organisations internationales, y compris la participation active de presque la totalité des pays méditerranéens.

Le présent volume le 16ème de la Série des rapports technique du PAM, englobe un choix de documents relatifs à l'action prioritaire intitulée "Promotion de la protection des sols comme élement essentiel de la protection de l'environnement dans les zones côtières méditerranéennes" couvrant sa première phase.

EDITORIAL

The objective of this paper is to present documents, reports and demonstration studies prepared within the priority action "Promotion of soil protection as an essential component of evironmental protection in Mediterranean coastal zones". The development of this project was guided by the idea to use the exchange of experience and co-operation between the Mediterranean countries for the introduction and promotion of an integrated approach to the management of catchment areas as the only way of achieving a rational use of land resources and maintaining stability and harmony in the entire environmental system. 15 Mediterranean countries have been taking active part in this priority action.

The papers contained in this volume of MAP Technical Reports Series are systemized in such a way as to reflect various phases of development of this priority action.

In the 1st phase, all forms of soil degradation were identified in the Region, as well as their effects on the environment of the coastal zones of various Mediterranean countries, and the experience in the study and prevention of those phenomena. A meeting of experts (Split, November 1985) discussed those problems and defined the strategy of co-operative actions, stressing particularly the problems of water-induced soil erosion and loss of agricultural land to non-agricultural purposes.

National reports, which the work in this phase was based upon, are presented here in the form of summaries within a synthesis report, because in the original form they were too extensive for such a publication. Only Egyptian and Italian reports are given in the original form to serve as examples representing two Mediterranean zones with significantly different bio-climatic and socio-economic conditions.

In the 2nd phase, case-studies were prepared throwing more light on the specific features of various segments of the selected problems under the specific Mediterranean conditions. By the selection of case-studies the following problems were stressed: (a) inventory of erosion phenomena; (b) study of the specific features of erosion processes under the Mediterranean conditions; (c) exchange of experience in the application of an integrated management of catchment areas exposed to erosion. To illustrate the problems of agricultural land protection from urban expansion, one African and one European country were chosen (Tunisia and Yugoslavia). The case-studies were presented in a seminar (Split, April 1987).

All the case-studies and the synthesis report are given here without shortening, because they present a great number of worthy data, often accumulated over a long period of time, which can be very useful for exchange of experience.

In the 3rd phase, the preparation was initiated of a co-operative project entitled "Inventory and Network of Erosion Measurement in the Mediterranean for an Environmentally Sound Land Management". All of the countries participating in this priority action showed great interest in this project.

Concept and framework of the project were presented in a separate document adopted by the seminar.

PAP/RAC hopes that this publication will be useful to professional institutions and experts dealing with soil protection, as well as to decision makers whose role in the protection of the Mediterranean environment is of utmost importance. It is expected that this publication will encourage further development of the co-operation between the Mediterranean countries in the field of soil protection as an essential component of the environmental system.

EDITOR

Prof. Dr Milivije Ciric
Co-ordinator of the priority
action on soil protection

EDITORIAL

L'objectif de cette communication technique est de présenter les documents, rapports et études préparés dans le cadre de l'action prioritaire "Promotion de la protection des sols comme élement essentiel de la protection de l'environnement dans les zones côtières méditerranéennes". L'idée directrice dans le développement de cette action prioritaire était d'introduire et de promouvoir, par le biais d'échanges d'expériences et d'une coopération entre les pays méditerranéens, une approche intégrée à l'aménagement des bassins versant, laquelle constitue la seule voie possible pour assurer une utilisation rationnelle des sols et maintenir la stabilité et l'harmonie de l'ensemble du système environnemental. Quinze pays méditerranéens participent activement à cette action prioritaire.

Les documents contenus dans ce volume de la série des Rapports techniques du PAM sont regroupés de manière à refléter les différentes phases de développement de cette action prioritaire.

Dans sa première phase ont été identifiés les formes de dégradation des sols dans la région méditerranéenne, leurs effets sur les milieux côtièrs dans différents pays et les expériences en matière d'étude et de prévention de ces phénomènes. Une réunion d'experts (Split, novembre 1985) a discuté ces problèmes et définit une stratégie d'actions coopératives, soulignant en particulier les problèmes liés à l'érosion des sols par les eaux de ruissellement et à la perte des terres agricoles au profit des utilisations non agricoles.

Les rapports nationaux, qui ont servi de base au travail dans cette phase, sont présentés sous forme de résumés au sein d'un rapport de synthèse, vu qu'ils sont trop exhaustifs pour être présentés intégralement dans ce genre de communication. Il n'y a que les rapports d'Egypte et d'Italie qui sont reproduits sous leur forme originelle en tant qu'examples de deux zones méditerranéennes possédant des caractéristiques bio-climatiques et socio-économiques très différentes.

Dans la deuxième phase de l'action ont été préparées des études de cas présentant plus en détail les traits spécifiques de différents segments de la problématique choisie. Lors du choix des études de cas on a voulu mettre en relief les problèmes suivants: (a) inventaire des phénomènes d'érosion; (b) étude des traits spécifiques des processus d'érosion dans les conditions méditerranéennes; (c) échange d'expériences en matière d'aménagement intégré des bassins versants exposés à l'érosion. Un pays africain et un pays européen (Tunisie et Yougoslavie) ont été choisis pour illustrer les problèmes liés à la protection des terres agricoles contre l'expansion urbaine. Ces études de cas ont été présentées lors d'un séminaire (Split, avril 1987).

Les études de cas et leur synthèse sont présentés sous leur forme originelle parce qu'elles contiennent de nombreuses données significatives, accumulées au cours d'une longue période et qui pourraient être très utiles pour l'échange d'expériences.

Dans la troisième phase a démarré la préparation d'un projet de coopération intitulé "Inventaire et réseau de mesures de l'érosion pour une gestion des sols sans préjudice à l'environnement". Tous les pays participant à cette action prioritaire ont exprimé une grand intérét pour ce projet.

Le concept et le cadre du projet ont été présentés dans un document séparé, adopté par le séminaire.

Le PAP/CAR espère que cette communication sera utile pour les institutions et experts oeuvrant dans le domaine de la protection des sols ainsi que pour les décideurs, dont le rôle dans la protection de l'environnement méditerranéen n'est pas moins importante. De même, on espère qu'elle encouragera le développement d'une coopération des pays méditerranéens en matière de protection des sols, qui constituent une composante essentielle du système environnemental.

EDITEUR

Prof. Dr. Milivoje Ciric
Coordonnateur de l'action prioritaire relative à la protection des sols

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Project outline prepared by PAP/RAC Consultant M. CIRIC

1. SOIL PROTECTION AS A PART OF ECOSYSTEM PROTECTION IN THE MEDITERRANEAN COASTAL ZONES

Soil protection in coastal zones is a subject which drew the attention and interest of the Contracting Parties to the Barcelona Convention, since it is an essential component of resource management and protection of the Mediterranean. Undoubtedly, the coastal zones constitute a particularly valuable resource in every Mediterranean country. These zones comprise integrated socio-economic ecological systems with a very delicate equilibrium which at present is seriously disturbed and threatened by inappropriate development in many cases. An important component of the coastal socio-ecosystem is its arable land, together with land offering natural support to any form of vegetation. Particular interest has been shown in cultivated land and woodlands, or abandoned or unexploited land, which may be brought into use for productive or protective purposes. In addition to their productive or protective function, such areas are part of the natural environment and thus have an impact upon its value conceived as a socio-ecological resource.

These were the reasons which prompted the Governments of Mediterranean States to entrust PAP/RAC with the formulation of the project.

It is worth pointing out the fact that UNEP, in the course of dealing with global problems of soil protection, has produced, in cooperation with FAO and UNESCO, a document entitled "World Soil Policy".

The approach of UNEP, or MAP-PAP respectively, to the above-mentioned problems is marked by a clear distinction in relation to the tasks and activities of FAO, namely, PAP is, in the present case, concerned with identifying and resolving the problems of soil protection in the coastal zones of the Mediterranean taken as a component of a healthy socio-ecological system and as a component of total coastal zone resources.

Based on this type of approach, PAP/RAC, in agreement with FAO representatives, will endeavour to harmonise the activities in order to avoid interference and to secure a fully co-operative and coordinated action.

2. BACKGROUND

The term "Coastal Zone" has been used here to denote a strip of land which extends along the coastline, and which is related to the sea through physical processes and the socio-economic activity of the population. The line delimiting the coastal zone from the rest of the hinterland is not uniform, and it varies according to the subject-matter dealt with. For the purposes of the consideration of soil problems, it is suggested that the boundaries of the coastal zone be assumed by following the watershed line which separates the catchment basins, and opens directly seawards, and to exclude those connected with the sea via transit rivers. The catchment basins, sloping down to the sea, constitute drainage areas from which the

sediments, nutrients and chemicals are conveyed to the sea directly and, consequently, affect the water ecosystems. Even from the visual point of view, these catchment basins form part of the unique seaside landscape, an important factor in evaluating the zone for the uses of Tourism. The borderlines of the large plains of the Mediterranean area, deeply indented into the land (e.g. the valley of the river Po, the North African coastal plains), which have been taken as the limits of such coastal zones, do not coincide with their natural boundaries which lie very far from the sea. Local experts must therefore decide whether such plains are to be considered as part of the coastal zone. If the answer is in the affirmative, they will have to define reasonable boundaries of such plains to make them conform to the recognised definition of coastal zone.

Specific natural conditions and types of land use, together with historical and economic development, have been a cause of intensive soil degradation in the Mediterranean area. There is tangible evidence that the decline of past civilizations in the Mediterranean was brought about as a result of soil erosion. The degradation of soil is a process starting with a decline in the productivity of the soil, which ultimately leads to the total destruction of the soil and its ability to support the growth of plants. Such changes are generated by various natural and man-induced factors. All of the forms of soil degradation that are known, occur in the coastal area of the Mediterranean but, among those which have the most severe consequences, are the following:

(a) Soil erosion

- runoff-water erosion
- karstic erosion
- wind erosion
- coastline erosion

Soil erosion may cause:

- a total loss of soil with a radical disturbance of ecosystems and hydrology
- the soil fertility to be impaired and, consequently, its productivity to be diminished to such an extent as to lead to the abandonment of the land after its utilisation has ceased to be economically justified
- the deposition of eroded soil particles in such a way as to silt up the water resources, and to engulf crops and fertile soil, coupled with other harmful effects.

(b) Salinisation and sodification

Salinisation and sodification are prevalent in arid parts of the Mediterranean region and are usually the side effects of uncontrolled irrigation.

These processes, together with the aeolean sand movement and other forms of soil degradation generate what may be termed "soil desertification".

(c) Direct deterioration of soil by forest fires

Forest fires occur very frequently in Mediterranean areas. Direct effects of forest fires are evidenced in burned organic matter of the soil, harmed organisms of the soil, abrupt changes in soil reaction, deterioration of the physical properties of the soil and changed soil climate. Since the renewal of forest cover over scorched land is rather hard to accomplish, it often happens that such land is abandoned and will ultimately be prone to accelerated erosion.

(d) Urban sprawl and pollution by industrial wastes

Expanding urban settlements, together with the growth of communication systems and other infrastructure facilities, lead to an irreversible loss of productive agricultural lands. The process is particularly marked in narrow coastal strips where population pressure is very high. Although there is a general trend towards avoiding the location of industries in the coastal zone, yet in some parts of this area the soil is exposed to poisoning by chemicals and to the deposition of solid particles emitted by industrial processes.

The outcome of soil degradation and urban sprawl is a continual reduction in agricultural land and forests, in quantity and quality, notwithstanding an increased demand both for food production and the protection of natural resources, landscapes and environment in general, which is most acute in tourist areas. Moreover, the socio-economic changes of the last decades, generated by rapid industrial and urban development (which have opened up more attractive employment possibilities), have occasionally provoked a withdrawal from arable land irrespective of its high productive capacity. It is, therefore, obvious that the protection of soil against erosion and urban expansion, as well as the re-use of arable lands, abandoned for whatever reason, must be given priority in implementing the general policy of soil protection in the Mediterranean region.

The significance of soil protection in the Mediterranean region is a broader issue than that of the mere preservation of soil, as constituting the resources for agricultural production. A considerable part of the region is covered with forests and other Mediterranean vegetation and, in addition to its primarily protective role in a wider context (soil protection, hydrologic cycling and local climate regulation), it also has a part to play in the aestnetic appearance of the landscape. Notwithstanding the need for a specific ecological approach, the soils of this area are also to be considered as a component of an integrated environmental system comprising the sea and its coastal zone. In this context, the soil constitutes an area of resources from which the sea is continually fed with nutrients and solid particles. Whether these processes are considered as fertilization or as pollution (eutrophication) depends upon the intensity of such processes.

Nevertheless, the strong influence of the state of soil upon the economic development of the area is also revealed in its impact upon man's appreciation of the sea.

The problems of soil protection have been the focus of UNEP's attention. Meanwhile the FAO has carried on an investigation of the soil over a period of years on a large international scale and, among other things, has dealt with soil protection. The results of these investigations, and the experience gained by FAO in this manner, have been presented in numerous manuals and

books of methodology, standards and criteria that may be applied, either in part or in their entirety, as a basis for anyone who wishes to undertake any activity in the field of soil protection. It would therefore seem wise to establish a close co-operation between UNEP-MAP and FAO, as occurred when MAP itself was created. The involvement of FAO should consist of its either joining the project, completely or partially, or of its participation after an agreement on coordinated activities has been reached and the roles clearly set up.

In spite of a great diversity of local conditions, the basic problems related to the protection of soil in coastal zones of the Mediterranean are common to the majority of Mediterranean countries, and the resolution of such problems evidently requires well-coordinated cooperation on a regional basis.

3. OBJECTIVES OF THE PROJECT

The principal objectives of this project are:

- to provide for the exchange of information and experiences in studying, preventing and overcoming the problems of erosion and non-agricultural use of arable lands as well as promoting the re-use of abandoned lands
- to identify current research activities related to the selected problems, and to set up by consent a coordinated programme of actions together with the examining of the possibilities for joint efforts of the participants in the assigned tasks within the framework of research activities
- to establish a basis for coordinated monitoring of the process and phenomena within the framework of the selected activities
- to identify the requirements and possibilities of providing technical assistance through exchanges of experts experienced in the subject-matter typical of the Mediterranean conditions.

For the purpose of identifying the specific targets that would enable the described principal objectives to be met, the participating countries should make national reports referring to the following topics:

3.1 Soil erosion

The transfer of knowledge and experiences cannot be implemented without a uniform classification basis. The national reports should, therefore, comprise information on the soil classification methods applied and indicate the possibility of correlating such classification with that of FAO-UNESCO. (A possible follow-up activity, related to the present problem, could be the forming of a Working Group whose task would be to present a Reference Base for classification of soils in Mediterranean zones).

An inventory of the areas attacked by erosion of various types and an assessment of the potential risk of erosion, are the first steps to be taken in developing soil conservation policy and in planning what action should be taken. Obviously, information on the methods applied in appraising the various types of erosion in each country of the Mediterranean, is essential. Also, references concerning the possibility of adopting "A Provisional Methodology for Soil Degradation Assessment" (FAO 1979) as a uniform basis to be applied in exchanging information and experiences seem to be necessary.

Should it prove to be a realistic aim, a coordinated project tentatively entitled "Global Inventory and Assessment of Actual and Potential Soil Erosion in the Mediterranean Zones" (Scale 1 : 1.000.000) could be launched. In any case, since FAO has already been involved in the project "World Assessment of Soil Degradation", the Organisation should be asked to include the above-mentioned activity into its global project.

Neither the problem of karstic erosion nor the methods of cartographic presentations of the soil mantle over limestone, which is characterised by extreme heterogenity, have been studied enough. Consequently, such a topic could be the object of a coordinated research programme. Registering the case studies, focusing on the present problem in individual Mediterranean countries, and references as to how the problem is viewed within them would also be helpful in defining the project.

The monitoring of the erosion processes is especially significant in soil erosion control. Thus the development of a common methodology in observing soil degradation and land use changes has been recommended in the document "World Soil Policy" (UNEP, 1982). The task of coordinating the development of the above-mentioned methodology should therefore include:

(a) the harmonisation of the methods applied in observing the dynamic factors and processes which constitute the mechanism of soil erosion. The monitoring programme should be designed in such a way as to allow for the data, obtained on a uniform basis, to be applied in mathematical modelling of the erosion processes;

(b) the concerted selection of localities in which to establish the permanent experimental sites assigned to form a network representative of the various Mediterranean regions.

The information on the existing experimental sites and the methods of monitoring, applied in individual Mediterranean countries, will reveal what is happening at present and supply a background for eventual future action.

3.2 Non-agricultural use of soils

The protection of soil against any kind of non-agricultural use is primarily a legal problem. The main principle to be followed consists in protecting the most productive agricultural land against the irreversible loss of such land due to urban expansion and the building of other facilities. The conflict among land users is to be resolved by adequate legislation, on condition that methods of proper land use classification and land evaluation have previously been developed, and the reasonable socio-economic factors respected.

The exchange of experiences, for the sake of establishing harmonised standards and passing appropriate legislation aimed at preventing the use of the best categories of soil for non-agricultural purposes, should be be focused on:

- an identification of the types of phenomena and their scope

- an explanation of the suitability of land-use classifications applied in differentiating the agricultural land allocated for protection, and demonstrating the suitability of the remaining classes of soils for various building developments

- a description of the legal instruments which offer protection to the most productive agricultural lands against their misuse
- comments on the problems raised with regard to the activities related to protection of soils against urban expansion
- recommendations regarding the forms of permanent co-operation in this field.

3.3 Re-activation of abandoned lands

Re-activating all the available soils in the Mediterranean suitable for agriculture, would contribute markedly towards increased food production and to the aesthetic improvement of the landscape. In addition, the ecological balance of the entire ecosystem would be significantly promoted.

As described above, there may be various reasons for abandoning agricultural land. A proper approach to the resolution of this problem would firstly consist of making an inventory of abandoned land, noting the reasons for such abandonment and commenting on the possibility of re-using them. The next step should be the establishment of a network of pilot areas, on the basis of such an inventory, which would function as models for defining the guidelines of further strategy and of the methods to be applied in the recultivation of abandoned land in the Mediterranean region.

I. DOCUMENTS PRESENTED AT THE EXPERT MEETING (SPLIT, NOVEMBER 1985)

I. DOCUMENTS PRESENTES LORS DE LA REUNION D'EXPERTS (SPLIT, NOVEMBRE 1985)

PROMOTION OF SOIL PROTECTION AS AN ESSENTIAL COMPONENT OF ENVIRONMENTAL PROTECTION IN MEDITERRANEAN COASTAL ZONES

Synthesis of national reports

by

M. CIRIC
Faculty of Forestry
Sarejevo, Yugoslavia

1. INTRODUCTION

This draft synthesis has been prepared on the basis of national reports produced by the Mediterranean countries participating in the project which is being carried out by the Regional Activity Centre for the Priority Actions Programme of the UNEP's Mediterranean Action Plan (MAP).

The basis for the national reports was the Project Outline and Terms of Reference, which described the major characteristics of soil degradation, determined the objectives of the project and set the course for its implementation.

In outlining the project, it was recognised that the soils in the Mediterranean coastal zone were exposed to various forms of degradation of which the major ones were erosion, salinisation and sodification. The natural conditions of the Mediterranean region encourage various forms of soil erosion, which includes a vulnerability of the vegetal cover to fire risks. Throughout history, the influence of humans has been a powerful stimulus of the degradation process, which has led to serious damage or even the irreparable loss of good soil.

In arid zones of the Mediterranean, salinisation and sodification can occasionally render large areas of land useless, thus resulting in their becoming desert areas. The processes of erosion and salinisation are in interaction on the coastal strip, since the erosion sediment maintains the necessary balance in many sections of the coast. An excessive inflow of the sediment may imperil aquatic ecosystems in the coastal zones, whereas a curtailed inflow of the sediment initiates erosion of the coastline, which diminishes fertile coastal lands in some parts of the Region. On the other hand, seawater causes salinity in aquifers and coastal plants.

Intensive urbanisation of coastal zones in all Mediterranean countries, particularly during the last decade, has caused heavy pressure on arable land through the extension of cities, industries and infrastructure, a process which by its aggressiveness and intensity outstrips the loss of land by degradation. This clearly accentuates the critical need for soil protection as a component of global production and the socio-economic system which is composed of the sea, the coastal zone and the local population.

Although various segments of the Mediterranean coastal zone differ in prevailing natural conditions and level of development, they share the crucial problems of soil protection. That is why co-operation among Mediterranean countries over the protection of coastal soils is eminently justifiable, even necessary, and has prompted the Governments of the region to entrust PAP/RAC with the organisation of co-operative activities within the framework of the Mediterranean Action Plan.

In accordance with the general principles of co-operation within the framework of PAP, this project is expected to provide and ensure:

- basic elements for the exchange of information, knowledge and experience acquired in the research and protection of land in the Mediterranean coastal zones;

- identification of research activities and current practices, with a view to setting up coordination and collaboration of individual efforts, and to exploring the possibilities of joint projects;

- exchange of experts and trainees as well as of various forms of technical assistance in the field of scientific research and land protection measures.

At this stage of the project, three phenomena will be dealt with in particular, since they seem equally acute in almost all Mediterranean countries. These are:

- soil erosion manifested in various forms;

- recultivation of abandoned productive land;

- protection of land from urban expansion and non-agricultural use.

2. SUMMARY OF NATIONAL REPORTS

ALGERIA

Author: Bualem Trabelsi, Ministry of Hydrology of Environment and Forests, Kouba, Algeria

1. Physical and geographical characteristics of the Mediterranean coastal zone of Algeria

The catchment areas orientated towards the Mediterranean Sea cover a total area of 13 million ha in Algeria, with a total water drainage of 12 billion m^3 a year. The relief is characterised by isolated coastal plains which are usually inadequately drained and have heavy soils. The plains are separated from the continental part by the Tell mountain ridges (1000-1800 m high) consisting of marls, clays and flysh.

The climate in the coastal zone is typically Mediterranean, with 600 - 2000 mm of atmospheric precipitations, rising from West to East, usually during the winter half of the year in the form of showers. The vegetation of the humid part is characterised by the Cedar, Quercus ilex, Corc Oak and maritime pine, whereas the semi-arid part is characterised by Aleppo pine and juniper.

2. Soil degradation in the coastal zone of Algeria

The topography of the terrain, which has a high percentage of steep slopes and a susceptibility of substrate to erosion, renders the coastal ecosystems vulnerable to erosion. The erosion process is set in motion after the devastation of forests and land uses customary for cereals and overgrazing, so that erosion now amounts to about 30% of the total area. The

extent of soil erosion in the humid part amounts to 16 m^3/ha a year, whereas in the semi-arid eastern parts it rises to 30 m^3/ha a year. The most severe erosion occurs in agro-silvo-pasture zones which make up 52% of the area, as well as in pure agricultural zones (13% of the area), whereas in forest zones (31% of the area) there is relatively little.

3. Reclamation of abandoned land

The Ministry of Forest, Water and Environmental Protection and its Directorate for Protection and Soil Reclamation are fighting against erosion, aided by a widespread network of national and regional institutions and associated legislation. As part of its strategy, it is worth noting the integral approach to catchment area management which involves an intensification of agriculture with the protection and promotion of soil and water resources and the promotion of the socio-economic position of the farmers. Afforestation has a specific importance for soil protection within this programme. Afforestation was carried out on about 250.000 ha over the period 1980-1984, and soil protection measures on 51.000 ha.

Experimental research is currently performed with the aim of discovering the erosion mechanism and that of erosion material transport, in addition to the development of erosion control measures. This is where the pilot project "Mina" belongs, a study which is to be used as a model for the development of a national strategy for the management of catchment areas in Algeria employing an integral approach. No less significant is the joint research carried out by three countries of Magreb (the Isser river catchment area), which is to result in the construction of a simulation model of the transport of erosion sediment and in the promotion of a general methodology of terrain surveying, observation and data processing. The experimental station Ouzera is equipped with experimental plots for erosion measurements under various soil treatments. The relevant complex of research projects is to include rain simulator experiments as well.

Large areas in Algeria (about 375.000 ha) have been the subject of erosion control measures.

4. Soil protection from urban expansion

In spite of a lack of agricultural land, the tendency of the expansion of urban and industrial zones towards valuable agricultural land is in progress. In this way, there has been a loss of 70.000 ha since 1962. Measures for the protection of agricultural land from urban expansion were enacted in 1974, and a long-term programme for soil reclamation in mountainous regions is in process, in order to try to prevent their innabitants from migrating into the towns within the coastal zone.

5. The need for and possibility of international co-operation

In co-operation with Mediterranean countries and thanks to PAP/RAC, the project of the elaboration of erosion map on a scale of 1:200.000 is of major concern. In order to proceed, it is necessary to identify and describe homegeneous terrains by means of aerial and satellite photos, to develop the data collection network, to elaborate the methods of terrain surveying, and to accept a single, common classification system.

Algeria is interested in acquiring knowledge and experience relating to the reclamation of grasslands, methods for estimation of land usability in catchment areas and in legislative activities for land protection. The support of the Institute for Forest Research of Algeria, and especially the supply of a rain simulator, would make a remarkable contribution to the work in the domain of soil protection in this country.

On the other hand, Algeria can offer its experience gained over several important projects, especially in respect of catchment management on the principle of an integral approach.

CYPRUS

Author: S. Pissarides, Ministry of Agriculture and Natural Resources, Nicosia

1. Physical and geographical characteristics of the coastal zone of Cyprus

Along the northern part of the island runs the calcareous Kyrenia Range (1,000 m), and in its central part there lies the Troodos massif (2,000 m) of igneous origin. Between these two mountain regions lies the large Mesaoria Plain which stretches down to the coast. The remaining part of the coast is a narrow strip of plain (2-10 km) which, in the north, abruptly ascends and merges into the Kyrenia Range. A zone of undulating terrain lies between the coastal plains and the Troodos massif (in the southern and the western parts of the coast).

The climate of the island is typically Mediterranean with mild and rainy winters (temperatures reach an average minimum of $9^{o}C$ in December) and hot, dry summers (average temperature in August is $35^{o}C$). Annual average rainfall is in the region of 500 mm, frequently in the form of short and intensive rainstorms. Moderate droughts occur once every 3 years, and severe ones every 10 years.

The natural vegetation consists of Cypress (*Cupressus sempervirens*) in the Kyrenia Range. Black Pine (*Pinus nigra*), together with Juniper (*Juniperus foetidissima*) and Cedar (*Cedrus brevifolia*) prevails in the Troodos massif. Aleppo Pine is the main forest species, and grows everywhere at elevations below 1,500 m representing 90% of the total growing stock. The destroyed forests have been replaced by maquis types represented by Golden Oak (*Quercus brevifolia*), Strawberry tree (*Arbutus andrachue*), Wild Olive (*Olea europaea*), Terebinth (*Pistacia terebinthus*), and the Carob tree (*Ceratonia siliquà*). The covering of garrigue is largely composed of species such as Lentisk (*Pistacia lentiscus*), Myrtle (*Myrtus communis*), etc. Among the crops grown in agricultural zones (mostly along the coast) are mainly cereals, vines, olives and carobs.

The report contains a soil map of the coastal zone which is Government controlled (296 km). Of the total area of 1216.8 km^2 controlled by the Cypriot Government, approximately 21% is coastal plain. The large plain between Famagusta and Larnaca is a plateau (60 m above sea level) of calcareous rock and rhodo-cromic cambisol (based on the FAO classification system), which has undergone considerable changes due to a strong human influence.

To the northeast of the plain, there are deeper soils, classified as eutric cambisols. The eastern part of the Larnaca coastal plain is affected by a high and saline water table giving rise to the development of solonetz and solonchaks. The southern and western part of the Cypriot coast is a narrow strip of land mostly consisting of calcaro-chromic cambisols, dissected by hills which at places descend to the sea. They are composed mostly of rendzinas and calcic lithosols developed on limestone, or of eutric lithosol on igneous rock. In the southern section of the coast there is an alluvial plain. The Akrotiri peninsula contains a salt lake surrounded by salty and sodic soils. The rivers run parallel down the mountain regions to the sea. The predominant soils of these regions are calcaric regosols and those of vertic characteristics.

2. Soil degradation in the Cypriot coastal zone

A high intensity of rainfall, the erodibility of parent substrata, tillage of steep slopes, frequent forest fires and excessive fragmentation of agricultural holdings are the factors contributing to soil erosion in Cyprus.

In the area of Larnaca, on June 15 1981, a rain shower was recorded lasting 4 hours (192 mm of rainfall) which caused 25 times as much soil loss by erosion as during the whole 1980-1981 rain period.

Annual erosion rate estimated in 1951 by type of land was 612 m^3 per km^2 in vineyards, 448 m^3 per km^2 in ploughlands, 339 in sparsely-forested areas, and about 77 m^3 per km^2 in densely-forested regions. These data denote that vegetation and land-use are decisive factors in erosion processes; almost a similar impact on erosion intensity occurred on the steeper catchment slopes.

Annual sediment load according to catchment slope

Catchment slope	Annual sediment load (m^3 per km^2)
- very steep (more than 8%)	400-600
- medium steep (4-8%)	250-400
- medium slopes (2.5-4%)	150-250
- gentle slopes (1-2.5%)	50-150

Detailed investigations undertaken in 1980 along with the Federal Institute for Geoscience of the Federal Republic of Germany, were based on the following criteria:

- a shortage of fertile land in Cyprus necessitates the protection of its soils. Within this context, a systematic collection of information on soil losses is an essential basis for developing appropriate management systems;

- Cyprus, being representative of the Eastern Mediterranean for its typical soils and climate and with its well-equipped network of meteorological stations, may turn out to be a model for the investigation of erosion processes by the Wischmeier method (determination of "R" erosivity factor);

- several meteorological stations cover different geological substrata and obtain evaluations of the relative erodibility of various substrata typical of the Mediterranean region. The results obtained indicated that marls are the most erodible, while landslides most frequently occur in the areas of bentonitic clays of the ammonia complex. The landslide phenomenon has been investigated in co-operation with the British Geological Service. These investigations could be taken as a case study which may be of interest for other Mediterranean countries.

Secondary soil salinisation and sodification in the coastal zone of Cyprus arise from irrigation with salty underground water, the quality of which deteriorates with over-exploitation of coastal aquifers. A systematic monitoring of the phenomenon showed that the level of underground water dropped by approximately 7 m in one decade (Mesaoria) due to overpumping which exceeds the safe annual amount of 20 mln. m^3, the result being the intrusion of seawater in all major aquifers of the zone. Therefore, strict regulations have been enforced in Cyprus for water pumping and they have stimulated intensive research work and efforts aimed at an increased utilisation of surface sources for irrigation.

3. Reclamation of abandoned agricultural land

A decline in land fertility caused by soil erosion, unsuitable relief, water scarcity and fragmentation of agricultural holdings below a critical level of profitability, are the key reasons for abandoning agricultural land (about 13.5% of land classified as abandoned) in Cyprus.

Cyprus is divided into 24 agro-economic regions, each facing specific problems. For example, the abandoning of the olive-carob regions is mostly caused by low productivity, scarcity of labour and frequent outbreaks of countryside fires. Vine zones are affected by difficulties such as the inaccessibility of hill slopes to modern technology, and by destruction of terraces. It has been decided that viticulture should be organised on more suitable sites, while abandoned vineyards should be reafforested. Fires are the biggest enemy of forests in Cyprus and their natural regeneration is a very slow process necessitating replanting, erosion and fire prevention control measures.

The Government of Cyprus has enacted the Land Consolidation Law which is expected to reduce all negative constraints in agriculture development and secure the optimum use of agricultural land.

4. Protection of agricultural land from urban expansion

An abrupt urban expansion occurred during the last decade in the coastal belt of Cyprus. Larger towns, particularly Limassol, have been taking waves of population influx. In Limassol, tourist facilities increased from 15% in 1973 to 50% of the total coastal tourist accommodations in 1978. The result of this fast development is the ribbon-type development along the coastline. A similar situation has developed in the coastal areas of Larnaca and Paphos where fertile land is also taken up by non-agricultural uses.

To avert the negative trends of development and protect national resources, the Government enforced the Town and Country Planning Law. Thus the regulations have been provided and criteria for land use set for

residential, conservation, industrial and agricultural zones. Also, the water supply boundaries of many settlements in the coastal area were fixed, and thereby indirectly stopped their encroachment on fertile soils.

5. The need for and possibility of international co-operation

A series of projects mentioned in the report may be of a wider regional (Eastern Mediterranean) importance and interest. Following this information, specialised institutions should prepare a concept and implement pilot projects or a co-operative network of research and demonstration sites. The author feels that, in developing co-operation, high priority should be given to soil erosion, salinisation/sodification and the protection of best agricultural soil from non-agricultural uses.

EGYPT

Author: Professor Dr. A.M. Balba, College of Agriculture, University of Alexandria

1. Physical and geographical characteristics of the Egyptian coastal zone

The Mediterranean coastline of Egypt extends to about 1.000 km. There are three major geomorphological regions: (a) the western region between El-Salloum and Alexandria (about 550 km); (b) the middle region between Alexandria and Port Said (400 km); and (c) the area of Sinai, between Port Said and Rafah (200 km).

The western coastal strip is 10-13 km wide. Its topography is marked by successive interchanges of ridges and depressions (ancient consolidated sand dunes and depressions between them) extending parallel to the coastline. The geological substrates are mostly calcareous Pliocene and Pleistocene formations covered by various types of recent deposits.

The geomorphology of the Middle Region is characterised by lakes and lacustrine flats, the flood plain of the Nile, coastal plains and sand dunes. There are areas of shallow water table between the lakes and in the depressions separating the dunes.

The Sinai region is a plateau sloping coastwards to the Mediterranean Sea. This region can be divided into three separate areas, the flat ones towards the west. They become waterlogged during the rainy season, and salty in the dry season. Gently undulating dunes are behind the flats and eastwards are closer to the coastline. The dunes are partially moving. This area contains a number of drainage basins fed by the water from the Sinai Central Plateau. The valley of Wadi El-Arich (1-3 km wide) with high sand dunes (40-50 m) constitutes the central part of the Sinai region. Separating the dunes is the El-Shiha plain with its deeply eroded surface forming deep gulleys. Further eastwards, there is a zone of sand dunes extending both towards the coastal and the desert part of the region. At its farthermost eastern end, there are gently undulating sandy areas which are cultivated.

The climate of the Mediterranean coast of Egypt is arid with about 90-180 mm of rainfall in the western region and about 74 mm in the central region, whereas the amount of rainfall in the eastern region gradually increases from 97 mm at El-Arich to 223 mm at Rafah. The amount of rainfall

abruptly decreases inland, so that the desert takes over as near as 50 km from the coast.

Rain comes within the period spanning September and March, most frequently as thunder storms forming torrents. The average annual temperature ranges between 23.9°C, and the relative air humidity is about 70%. In the period between March and May it can drop to only 10%. Evaporation rates are high, particularly in summer (3.9 - 7.9 mm/day). Due to aridity, the scarce natural vegetation cannot substantially add to the stability of the ecosystem.

The soils of the eastern and western regions are calcic, ochric solonchak (appearing as a saline phase of the afore-mentioned soils), gypsic yermosol (at places containing layers of hard gypsum), lithosol (on limestone-elevated areas and in the eroded lowlands), and arenosol (characteristic of sand dunes). In the region of dry lake beds there are saline soils of a heavier texture with frequent gypsum layers. In the middle region of low dunes the soil is fine sand, rich in $CaCO_3$. South of it, the land is made of fluvio marine deposits with saline sodic soils. Vast areas of the territory were drained, desalinated and irrigated with Nile water, and are now cultivated.

2. <u>Soil degradation in the Mediterranean coast of Egypt</u>

Water erosion is caused by a moderately high rainfall index (50), according to the estimates made after a FAO method (1979). The consequence is an intensive run-off and gully erosion which is particularly accentuated in El-Arich valley substrata. Sheet erosion is also widespread, especially where the natural vegetation is scarce.

Wind erosion affects large areas of loose sand, the wind erosion index (FAO classification) being 150 in the western region, and ranging between 50 and 100 in the other two regions. Approximately 50% of wind velocity is above 20 km/hr, making wind erosion a highly acute problem in Egypt.

Seawater erosion of the coastline started to appear especially after the construction of the old Assuan dam stopping the inflow of Nile deposits which amounted to 70-80 million tons annually, and thereby disturbing the balance between seawater erosion and the inflow of inland deposits. The result was a heavy erosion of the coastline which retreated inland 70-80 m a year between 1964 and 1970, and about 180 m between 1970 and 1982.

The research and monitoring of the process is under way while a special Government organisation has been entrusted with the execution of projects for the construction of walls to protect the coast. This is a colossal project which could be used as a case study for the transfer of knowledge and the exchange of experience with other Mediterranean countries.

3. <u>Reclamation of abandoned agricultural lands</u>

The necessity of reclamation of the eastern and western coastal regions has become urgent, since the population density in the Nile delta has reached 2,000 inhabitants per 1 km^2. That is why as early as back in 1960 full attention started to be paid to the recultivation of land in the western region, whereas due to a special situation that became possible in Sinai only in 1983.

Two basic guidelines of land reclamation have been envisaged. In the western region, the Nile water is to be introduced in the 150 km long coastal strip to enable irrigation for agriculture. Priorities in reclaiming new arable lands have been made on the basis of a land classification scheme prepared in 1967 by Balba and El-Gabaly.

In the eastern region, a modern way of dry farming with dates, figs and olives as main crop production has been developed.

Salinisation and sodification in the coastal areas adjacent to the sea is a widespread phenomenon in Egypt, particularly close to lakes, lagoons and swamps. Being related to irrigation, it must be taken into account as a significant factor in land reclamation where irrigation is needed.

4. Protection of agricultural land from urban (non-agricultural) expansion

The problem of protecting the productive agricultural land from urban expansion is specially grave in Egypt. The heaviest pressure on agricultural land has been felt in the Nile delta where concentrations of people are the highest and where almost all the land is highly productive. Thus, the only possible choice for urban expansion is to penetrate into the productive land. Additionally, brick industry is now dependent on removing the top layers of the cultivated clay soil (to a depth of 20-100 m) causing ground water to approach the surface.

Although the Government has passed and enforced a rigorous law protecting the agricultural land from being subjected to any form of non-agricultural use of land in the Nile valley by decision of the Ministry of Agriculture, noticeable effects can be expected only when the wider areas outside the delta have been recultivated.

5. The need for and possibility of international co-operation

Egyptian experience in dry farming technologies seems to be limited, while expanding agricultural production in areas which depend on scanty precipitation is a necessity for Egypt. That means making maximum use of available rainfall, control of surface run-off, and ground water conservation. Since this is not an easy task, Egypt needs international assistance in installing monitoring stations and developing monitoring methods, in the preparation of hydrological studies for special areas, and in the training of national specialists.

Egyptian experts have a wide experience in the field of desert ecology in coastal zones and can, in turn, extend their assistance in the preparation of soil and hydrology studies.

The College of Agriculture in Alexandria is now preparing, with the co-operation of American universities, a complex joint project for integrated applied research and protection of resources. The project envisages training and exchanges of experience with competent international institutions.

The author of the national report suggests that the exchange of experience among Mediterranean countries be effected through the exchange of publications, periodicals, meetings of experts, organisation of joint seminars and exchanges of under- and post-graduates.

FRANCE

Author: M.F. Fournier,

1. Physical and geographical characteristics of the Mediterranean coastal zone of France

The Mediterranean coastal zone of France is a narrow coastal strip backed by the ridges of the Alps, the Pyrenees and the Central Massif. The important part of the zone is the Rhône valley and the adjacent plains (up to 100 m above sea level) to the west (Languedoc). The lowlands between Marseille and Nice are confined to a very narrow coastal strip flanked by the calcareous and siliceous slopes of the Alps.

The climate is typical of the Mediterranean, with a dry and warm summer and a rainy autumn and winter. The amount of rainfall ranges from 500-700 mm in the western part of the zone, to about 700-1.000 mm in the eastern part. The average annual temperature is above 14 °C.

The evergreen oak, carob, Aleppo pine, lemon and orange trees, olive trees and vineyards comprise the prevailing vegetation of the area.

Rendzina and lithosols are associations appearing in the soils of the calcerous elevated areas (slope above 8%), whereas chromic luvisol (terra rossa) is typical of the undulating area along the coastline. Distric and eutric brown soils prevail in the area west of Toulon, while fluvisols occur in the coastal lowlands (Languedoc) with hydromorphous soil appearing in the Rhône delta.

2. Soil degradation in the Mediterranean coast of France

The author points out global facts which have to be taken into consideration in order to understand the situation in the Mediterranean.

(a) The dry climate in summer diminishes the protective role of the vegetation cover while torrential rains tend to increase the erosion hazards. Therefore, traditional agriculture makes use of various forms of soil protection, cultivated terraces being the most important. Their adjustment to contemporary economic and technical conditions is a delicate problem.

(b) To a degree, humidity stimulates the development of the vegetative cover and prevents run-off but, when excessive, it causes moving of soils on marl substratum, the control of which is an important issue.

(c) Erosion and the consequent state of vegetation exert a powerful influence on soil degradation.

Although the processes and mechanisms of erosion have been thoroughly studied in France, its Mediterranean zone has been rather neglected in this respect. On the other hand, depending on past experiences, it is difficult to accept since the changes which took place in agriculture in the 19th century could not consider and include the soil protection component. However, the new requirements of agricultural development have reconfirmed the acuteness of erosion problems and other forms of degradation. In the review "Forêt méditérranéenne" (Vol.II, No.1, 1980) G. Duclos published his value assessment

method for soils on sloping terrains which can be applied to various situations in the Central Mediterranean. He has pointed out factors which must be taken into consideration in land improvement to obtain a maximum degree of protection (slope, substratum, soil depth, texture and potential fertility of different layers, soil chemistry, erosion risk, and other specifics pertaining to soil). In the same review, H.N. Le Houreou discusses the anthropogenic impact on Mediterranean forests and how their degradation reflects on erosion and sedimentation. These examples denote that there is considerable documentation in scientific papers on the problems of soil protection in the Mediterranean although it has not been collated and applied in the form of concrete projects.

The first project on the erosion of arable land in the area of Languedoc is under way, and it could be used as an example of how the problem of soil protection has been tackled in the Mediterranean coast of France. The reasons for initiating the project were motivated by the following problems:

- the monoculture of vineyards with a uniform agro-technique and without any attempt to adapt it to various habitats, (local) conditions;
- insufficient natural (organic) regeneration of vineyards;
- lack of proper cultivation, this being a frequent practice with vineyards;
- removal of terrace walls and felling of trees to facilitate mechanisation, which stimulates erosion processes;
- efforts to introduce diverse crops;
- restructuring of land taking no account of ecological and geomorphological impacts.

3. Reclamation of abandoned agricultural lands

The author has not dwelt specifically upon the problem, but it is possible to arrive at the conclusion that reclamation of abandoned vineyards on terraces is an acute problem in France which has been dealt with in the project mentioned in the previous chapter.

4. Protection of agricultural land from urban (non-agricultural) expansion

This report has not considered the issue.

5. The need for and possibility of international co-operation

The discussed project is suitable for international co-operation, in accordance with the global approach explained in PAP document PA-8/ME/5102-83-05.

ISRAEL

Authors: R. Keren and B. Yaron, Agricultural Research Organisation, Betdagan

1. Physical and geographical characteristics of the Israeli coast

Israel is divided from west to east by several parallel physiographic-lithologic regions: (a) an undulating coastal plain with sandy sediments in the west and fine-textured aeolian deposits in the east; (b) a central mountain region of rocks, mainly limestone, dolomite, chalk and marl; and (c) an eastern rift valley with various alluvial carbonate lacustrine sediments.

The coastal plain of Israel has a typically Mediterranean climate. The rainfall decreases in general from north to south varying from 800 mm to 200 mm respectively. It is also locally affected by the orography and exposure. The rainfall intensity can be very high (as much as 500 mm during a few days). The average annual temperature in the coastal strip ranges between 17°C and 21°C.

The natural vegetation consists mainly of xerophytic forest and shrub in sub-humid areas, and of xerophytic grass cover in arid areas. The tropical summer rainfall region is characterised by a high savanna vegetation.

In the coastal plain various vertic soils are predominant which merge into planosol on the moderate slopes of the sub-humid areas, or into solonchak and solonetz in arid regions. Fluvisols are restricted to flood plains. The prevailing soils at the footslopes are chromic and brunic luvisol, in the upland areas there are lithosols, while rendzinas are found on limestone. Pheozem and eutric cambisol occur in cooler climatic zones.

2. Soil degradation in the Israeli coast

In the semi-arid region the natural vegetation cover is sparse, causing the natural erosion process to be more widespread than in semi-humid areas. Generally, erosion has left visible marks on the genesis and landscape in Israel. Human impact on water erosion has been long and intensive throughout history. However, the author maintains that the erosion hazard is much greater now than in the past, because the contemporary agro-technical intervention increases the erosion risk (for example, herbicide application leaves the soil surface clean of vegetation while heavy machines diminish the soil infiltration rate causing run-off). Cotton, the major crop in Israel, leaves the land naked and thus exposed to run-off in winter when the intensity of rainfall is at its heaviest (30-50% of total).

Extensive research carried out in Israel confirmed the decrease in the infiltration rate of soil is mainly the result of the formation of a dense surface crust, due to the effect of exchangeable sodium. The electrolute concentration in soilwater can play a moderating role in the process (the higher the electrolyte concentration, the higher the infiltration rate). The knowledge that the absorbed Na+ ion is of key importance in the formation of the surface crust and thus the crucial factor of erosion in arid regions, points to the fact that gypsum treatment of the soil is the best measure for checking erosion. Research into these processes in Israel has a wide regional significance and is relevant for all arid soils of a clayey texture in the Mediterranean.

Together with the experimental studies carried out in the Negev desert and the Pleshet plain, it can be presented as a case study.

In the central part of the coastal zone (the Sharon region), coastal (beach) erosion is very intensive causing the coastline to recede approximately 1 m a year. The erosion of coastal cliffs has been largely influenced by human activities (uncontrolled drainage of urban run-off, construction of water reservoirs in the vicinity of erodible cliffs, residential building along the coastline). There is a national plan which strictly controls the development along the erosion-stricken section of the coast, and envisages the construction of protective walls.

3. Reclamation of abandoned lands

The report does not address this topic.

4. Protection of land from urban expansion

Of Israel's total area of about 2 million ha, only about 550.000 ha is suitable for cultivation, approximately 130.000 ha being in the coastal zone where half of the Israeli population lives. The intensive industrialisation and urbanisation of recent years has brought about the loss of open space and its replacement by biologically degraded urban and industrial areas, neotechnological despoilation, and pollution of soil, water and air.

Close to 94% of land in Israel is under the control of the Israel Land Authority (ILA). This organisation has issued regulations which give the highest priority to agricultural land. A Planning Law (1965) resulted in the establishment of the Committee for the protection of agricultural land. Of its eleven members, many are directly or indirectly interested in agricultural land. The selling and parcelling of farming plots are prohibited in Israel and land is only leased. The ILA takes any decisions as to the change of uses from agricultural to urban.

Co-operative farms are the predominant form of agricultural production, since shared interests can more successfully counteract and resist the loss of agricultural land.

5. The need for and possibility of international co-operation

In-depth studies of erosion processes in specific conditions of soil sodification may be of great significance for other arid Mediterranean regions. That is why the author suggests that this be used as a case study. Furthermore, Israel has developed the technique of rain simulation which is essential for research into erosion mechanisms. Pointing out the excellent properties of the simulator, the author recommends its application in other Mediterranean countries.

ITALY

Author: F. Mancini, Institute of Applied Geology, Faculty of Agriculture, Firenze

1. Physical and geographical characteristics of the Italian coastal zone

The Italian coastline is about 9,000 km long and geographically very diverse. The section of the coast between the French border and the mouth of the Magra river (the Ligurian Coast) is rocky. The neighbouring coasts of Tuscany and Latium are characterised by several larger plains interrupted by a

series of mountain ridges. The entire coastal part of Calabria south of Sorrento is also rocky, dissected by narrow valleys opening up into wider river plains. The Lucania coast is a large cultivated littoral flat, Apulia is generally rocky except for the area north of Bari, right down to the Gargano promontory which is flat. North of Bari up to Pescara the coast is rocky and further off between Pescara and Ancona it is generally flat with a series of parallel rivers running down the Apennines. From there to the Yugoslav border the littoral is flat, merging into a succession of large plains ending in the Po delta.

The islands of Sicily and Sardinia have several large river valleys, but the major part of their coasts is rocky.

The entire coastal zone of Italy enjoys a mild Mediterranean climate with the marine influence more strongly felt in the islands, and the continental influence (strong winds, and occurrence of snow) reaching down to the Trieste Bay. The average annual temperature is 14-15^{o}C in the northern section of the coast, and 16-17^{o}C in its southern part. The amount of rainfall ranges between 600 and 1,200 mm depending on the geographical lattitude and the proximity of the mountains.

Vegetation of the Italian littoral has been strongly influenced by human activity and a large part of the coast was cultivated in pre-history times. The natural vegetation is represented by two major associations: the Oleo-Ceratonium association (olive and carob trees) in combination with shrubs such as the myrthe and the tamarisk in more arid and warmer areas, and with the evergreen oak prevailing in more humid sections of the coast on deeper soil. The warmer habitats up to 300-400 m are the areas of the maritime pine (Pinus pinaster).

The soils of the Italian coastal zone are predominantly fluvisols (plains), cambisol (on undulating terrain), and luvisol which covers the largest part of the coast. Terra rossa (chromic luvisol) can be found on hard mesozoic limestones. Vertisols in combination with regosols are spread on undulating clayey terrains, mostly in the Adriatic coastal zone. An atlas of the Italian coasts has been recently published in the framework of a soil conservation project.

2. Soil degradation in the Italian coast

The crucial problem of the Italian coast is water erosion, but occurrences of wind erosion have also been reported.

Sheet erosion is typical of gently sloping cultivated areas, and gully erosion occurs on steep slopes in silty clays of Pliocene and Pleistocene marine origin, and in pyroclastic materials covering volcanic districts.

Run-off washes away fine soil particles while clogging the river beds with coarser materials. A comparative analysis of aerial photographs taken over a 12-year interval showed that the accumulation of coarse gravels extends to half a metre a year.

Recent research into water erosion has been geared in two directions: (a) better understanding of the factors influencing erosion processes; and (b) identification of erosion risk.

The intensive soil erosion in Italy is primarily due to an unfavourable distribution of rainfall and the intensity of rainfall. In Calabria, for example, 4-5 days of continuous rain (300-400 mm/day) are not infrequent. Another phenomenon which also stimulates erosion is frequent forest fires.

Italy can boast a long tradition in land improvement and its protection from erosion and floods. In central Italy, engineers and agronomists have been building dams, terraces and other protective structures since the 18th Century. Today, under the supervision of the Italian National Council for Research, these are organised by a number of research institutes for hydrology and soil protection (listed in the report) which are ready to take part in an international co-operation.

In many places a regression of the coastline has been recorded as the result of seawater erosion. Subsidence of the alluvial plains is a specific problem. Some of these plains are sinking at the rate of 1 cm per year, and some as much as 4-5 cm. In addition to natural causes, this phenomenon is encouraged by human activities (heavy structures, disposal of wastes, pumping of water and gas) which cause hydromorphism to increase and land to become saline, and thus unattractive for farming.

3. Recultivation of abandoned agricultural lands

Many agricultural lands on steep slopes have been abandoned particularly those soils which are easily eroded, shallow and infertile (for example "fasce" in Liguria). The author maintains that these terrains should be left for reafforestation. In the same zone, but on less steep slopes, agricultural production has continued and developed with the help of irrigation.

In southern Italian regions vast areas were re-afforested after the war and today they produce good timber. The Government aids the process by acquiring thousands of hectares of land for afforestation, and by supporting agriculture only on the best soils.

Abandoning of land in subsiding alluvial plains is a serious problem, because their reclamation requires extensive action. One such attempt is pumping river water into deep water tables in areas of subsidence caused by exploitation of aquifers and gas.

4. Protection of agricultural land from urban expansion

Urbanisation of the Italian coastal strip is extremely intensive and is primarily due to:

(a) decrease of interest in agriculture (better employment opportunities in industry and tertiary activities);

(b) development of new industries along the coast;

(c) retired population and farmers who abandoned their land and moved to the coast for good; increased housing development and the construction of secondary homes (weekend houses);

(d) development of large tourist complexes.

About 200.000 ha of arable land have been lost in that way over the last 20 years. A typical example of this is the "Riviera Romagnola" which has become an uninterrupted 50 kilometre line of residences.

The national report contains a very instructive map of the urban area of Gliari (Sardinia) showing in 1954, 1968 and 1977 the edges of the town which has rapidly eaten into the surrounding agricultural land. The author insists on the necessity of having adequate maps of land suitability and advocates the principle that the I- and II-category soils be fully protected. With such maps taken account of in urban plans, some good results have been already achieved, particularly in Piedmontsa. The author also points out the need for a national service for research and protection of soils to be entrusted with the preparation of a single, common soil classification system and to take part, together with architects and urban planners, in the preparation of urban plans.

5. The need for and possibility of international co-operation

The exchanges of experience among Mediterranean countries should be effected through visits of experts, joint and/or coordinated projects, and through exchanges of relevant books and publications. To meet this aim, there should be established a special body (centre or service) for soil protection which would be permanently responsible for carrying out the activities.

Italy has a wide experience and a number of institutions with interdisciplinary teams dealing with the protection of soil, so that less developed Mediterranean countries could benefit from co-operation with Italy.

LIBYA

Author: Dr Khalil A. Suliman,

1. Physical and geographical characteristics of the coastal zone of Libya

The coastal zone of Libya extends from Tunisia and Egypt and is 1,900 km long. To the west, on the borders of Tunisia is the Jefara plain, 80 km large, with sporadic sand dunes. On the south it is flanked by a plateau 600-1000 m high, rising steeply from the plain. Further to the east, the coastal plain is only 3.5 km, extending to 22 km near Misurat. From Misurat to Benghazi the coastal zone is a plain with sparse sand dunes continuing to the north-west as the Jebel Akhdar plateau 50 km wide and 1000 m high, on the borders of Egypt. Its topography is typically karstic.

The climate of the coastal zone is characterised by an abrupt decrease of precipitations from 200-300 mm (in the vicinity of Derna 500 mm) to 50 mm at a distance of only a few dozen kilometres from the coastline. The rainfall distribution is Mediterranean, with the highest concentration in the autumn/winter period. The temperature is characterised by large oscillations between winter and summer (12-40 ^{o}C). Strong winds blow from the deserts in the mainland.

The natural vegetation is xerothermic grass cover, maquis and pseudomaquis with some typical Mediterranean species (Juniperus sempervirens, Ceratonia siliqua). In the drier central part of the coastal zone there are Sahara desert plants and halophytes found on solonchaks.

The soil cover is shown on a pedologic map on a scale of 1:50.000 with accompanying thematic maps (salinisation maps, erosion maps and land capability maps). The prevailing soil type is yermosol, and in the area round Akbdar about 25% of ferralsol is found, while in the west part there are chromic cambisols. Small areas of vertisol and fluvisol are also found in the lowlands, and solonchaks account for 15% of the surface. On calcareous rock prevail rendzinas and lithosols, and aeronosols on sand dunes.

2. Soil degradation in the coastal zone of Libya

There is a problem of soil erosion in the coastal zone of Libya, since 70-80% of surface is exposed to wind and water erosion. Factors contributing to this high level of erodibility are light texture, sparse vegetation, low content of organic matter, overgrazing and inadequate agricultural machinery. Water erosion, especially acute on the highlands in the background, occurs in the form of sheet and gully erosion, while large surfaces in the coastal zone are affected by an accumulation of sand dunes.

There is a project of complex measures of soil protection against erosion developed by experts from the Soviet Union. Valuable positive experience is gained in combating wind erosion. Different methods of sand dune consolidation are applied, such as dry vegetal matter, by means of petroleum emulsions, and synthetic bitumen (resin), developing protective forest belts, and others. This experience can be usefully applied to arid regions of Mediterranean countries. Water erosion is controlled by means of terracing, mechanical constructions in river beds, contour tilling, erection of barriers, etc.

3. Reclamation of abandoned agricultural land in Libya

Agricultural land in the coastal zone of Libya amounts to 3.000.000 ha, of which 2.400.000 is arable. As a substantial part of agricultural production depends on rainfall, some land during periods of drought is abandoned. Permanent abandonment occurs on lands that become salinised due to the intrusion of seawater into the subsoil, or on land affected by erosion. Grazing lands are also abandoned when their productivity becomes low as a result of irrational exploitation.

The reclamation of abandoned land depends on a better regulation of hydrological systems and erosion control. Special attention should be given to the use of waste water from the sewage systems for irrigation, after adequate treatment. The author enumerates six major projects which solved the problems of irrigation, pasture improvement, construction of artificial water accumulations and afforestation.

4. Protection of land from urban expansion

Land suitability classification for regions with more than 200 mm of rainfall has been carried out. It defines seven categories of land, with the last three classes which are unfit for agricultural production accounting for 1.600.000 ha. However, the available data show that it is urban growth which consumes the best classes of land mostly. In 1978, urban built-up areas took up 17.6% of the best quality land, 6% of good land and 1.6% of medium quality land. Because of Libya's need for agricultural land, laws were passed establishing the competence of the Secretariat for Agriculture in all matters of use and possible cases of parcelling of agricultural land. The drilling of wells is also the responsibility of the same Secretariat. Every major town

has a development plan covering the period up to the year 2000, which should prevent further endangering of agricultural land by urban expansion.

5. The need for and possibility of international co-operation

The Libyan expert underlines in particular the need for co-operation of Mediterranean countries in solving the problems of improvement of saline soils, of compensation for water pumped from the subsoil, and of the assessment of soil loss due to wind erosion. Libya can offer its experience in consolidating sand dunes, in improvement of mountain soil and in improvement of grazing lands. The most important project in Libya is the development of a forest belt in the southern part of the coastal zone, intended to prevent further desertification (an international project).

MALTA

Author: P. Muscat, Department of Agriculture and Fisheries, Valletta

1. Physical and geographical characteristics of the coastal zone of Malta

The Malta islands consist of Malta (246 km^2), Gozo and Comino (each 316 km^2). With regard to its topography, the entire territory belongs to the coastal zone. The main part of the island of Malta is hard limestone core, up to an altitude of 250 m. This core is surrounded by blue clays. The central part is a plain with soft globigerine limestones. From the west highlands, river valleys descend to the east and the southeast. A similar structure is found on the other islands.

The climate of the Malta islands is typically Mediterranean with dry hot summers (mean July temperature is 30°C), and humid mild winters (mean temperature for January-March period is 15°C). The total precipitation varies between 200 and 970 mm. The relative air humidity is in the range of 65-80%. The prevailing wind is from the north-west and can reach a velocity of 9.1 knots/hr causing aeolian erosion.

The natural vegetation cover is composed of evergreen forest degraded to garrigue (jessamine, carob, evergreen shrubs), and frequently Aleppo pine is found on these degraded surfaces.

On some limestones and blue clays, highly carbonated recent soils of regosolos and rendzine type are present, and on hard karstified limestones - terra rossa and lithosols. Fluvisols are found in the river valleys.

2. Soil degradation in the coastal zone of Malta

The most serious form of soil degradation on the Malta islands is water erosion. No sufficiently accurate measurement of the level of erosion has taken place. The combined erosive effects of rain, sparse vegetation, mountain landscape and substrata of high erodibility, are responsible for all aspects of water erosion. Torrential runoff often destroys protective terraces, which are common in this region. Eroded soil material is sedimented in the plains, most of it ending up in the sea and causing additional damage.

Soil degradation imposes the additional use of chemicals which aggravate the pollution problem and cause biological degradation of soil and environment.

Inadequately-built irrigation systems lead to swamping and sinking of the ground.

The necessity of an integrated approach to erosion problems is emphasised, with one central agency to coordinate various specialised aspects. The main protective measure is the terracing of slopes, Malta having made use of this traditional technique since the 19th century. The need to cultivate the land properly and to afforestate the higher parts of the slopes is also stressed. A major government afforestation project is now under way, including the development of forest belts as a protection against wind erosion. Variable experiences in this aspect have already been gained.

3. Recultivation of abandoned agricultural land

In the report, though no data are given on abandoned agricultural land, it can be concluded that efforts have been made towards land improvement and reclamation, and the activation of barren land. Since 1976, 120.000 m^2 of land has been improved or reclaimed every year. Particular attention is given to the enrichment of soil with organic matter, which also increases soil resistance to erosion.

4. Protection of agricultural land from urban expansion

Very swift growth of industry, tourism and urban expansion has lately seriously threatened the productive agricultural land. Therefore, in 1973, the Act was adopted on productive land protection. The intention of this Act was to prevent the transportation of soil from one place to another; to prevent covering fertile land with sterile material; to stop unplanned development. Its enforcement is very strict, and the Director of the Land and Water Department has full authorisation as to the adoption of decisions. Special Land Control inspectors are in charge of enforcement control.

5. The need for and possibility of international co-operation

In Malta, great attention has been paid to farmers' education, which is expected to improve proper land utilisation. Co-operation in this field would obviously be very profitable.

MOROCCO

Author: El Imbrahimi Abdelkader, Diour Al Koumir, Trabiquet salé

1. Physical and geographical characteristics of the Mediterranean coastal zone of Morocco

Out of the 3000 km long coastal zone of Morocco, one third belongs to the Mediterranean coast. The coastal zone is divided from the continent by the Rif mountains (altitude 2000 m) through which numerous water courses cut their way to the coast. In this region there are a number of plains of limited size.

Geological parent rock is of a wide variety: limestone, sandstone, marls, crystalline slates and various forms of flysch. In the coastal alluvial zone, there are frequent occurrences of quaternary sediments. The type of soil depends on the parent rock and are predominantly distric cambisols, luvisols, rendzinas, regosols, and in the flatland fluvisols and vertisols.

The climate of the Moroccan coastal zone is typically Mediterranean, with precipitation concentration in the winter period, frequently in the form of showers. The annual precipitation value varies from 800-1000 mm in the west, to 500 mm in the east. The mean annual temperature in the lower zones is 17-18°C, decreasing with higher altitude. In the mountains above 1600 m strong winds frequently occur.

Natural vegetation cover in the lowest zone consists of associations of Oleo lenticetum, followed by different species of Mediterranean oak together with typical shrubs (lavender, Erica). Vast surfaces are afforestated with species of Eucalyptus, Acacias, Populus, as well as different species of pine (radiata, pinaster, pinea, canaris, brutia, haleppensis).

2. <u>Soil degradation in the Mediterranean coastal zone of Morocco</u>

In Morocco water erosion is the most acute problem of soil protection. Therefore, it has been a central concern of responsible institutions since 1951, when the first laws and regulations on soil protection were enacted. These activities are founded on a long tradition of afforestation and fruit- and vine-growing on terraced slopes. Starting from 1971, erosion protection action in Morocco was intensified. Important projects carried out with the assistance of international organisations have been undertaken. Such is the MOR project in the watershed area of Nekor, executed in co-operation with FAO. The Nekor basin has a surface are of 78.000 ha, which is believed to be the most erodible in Morocco. Erosion protection measures have to be applied to 20.000 ha, 40% of which consists of slopes over 50%, while only 18% of the surface is under the 18% slope. The intensity of erosion is about 8000 t/ha a year. This is, at the same time, a densely-populated area, with 75 inh/km^2, with a rate of growth of 2.7%. About 50% of the surface is arable land and forest, 35% of it under perennial cultures, and 8.5% under arboriculture. Classification of physiographic units within the area has been carried out. Each category has received a different treatment, which takes account of factors such as land classification, climate, soil quality, geology, hydrology and other indicators.

The DERRO project in the East Rif is similar, covering 250.000 km^2, with the difference that it also includes socio-economic aspects. Several pilot studies were used in the elaboration of projects of integrated development. By means of intensive treatments (afforestation, improvement of grazing lands, development of fruit-growing, melioration of eroded areas, etc.), 150.000 ha have been reclaimed since 1985.

Each of the above projects has a broad significance for the Mediterranean region, as integrated projects with well-elaborated methodology and rich experience.

3. <u>Recultivation of abandoned agricultural land</u>

In Morocco, it is mostly the shallow soils on slopes that are abandoned, as a consequence of inadequate land cultivation and erosion occurrence. Afforestation has proved to be the only reasonable method of reclamation, especially in less populated areas, and this is widely applied in Morocco.

4. Protection of agricultural land from urban expansion

The largest towns in Morocco are in the coastal zone and they expand at the expense of agricultural land. The urban population growth reached 5.6% rate in the period 1971-1982, but rural population increased by only 0.9%. This illustrates the high level of urban development. So far no law has been passed to protect arable land from urban expansion. Towns continue to be the centre of gravity of economic development.

5. The need for and possibility of international co-operation

The methodology and technology developed in Morocco can have a broad application in the Mediterranean coastal zone. In a departure from physical structure and socio-economic elements, as well as from land utilisation modalities, the following sectors for project execution in Morocco have been singled out:

(a) towns with more important rural agglomerations, including industries;

(b) plains with gently sloping zones (suitable for cereal and fruit growing);

(c) mountainous land (forest pasture zones);

(d) high mountain zones (forest regions necessitating application of specific land-protection measures);

(e) integrated lands.

There have been interesting experiences with regard to the afforestation of erosion-attacked land. The results arrived at in Morocco in respect of this problem are valuable and are corroborated by numerous data on each of the five characteristic sectors.

TUNISIA

Author: Dr Souissi, Department of Soils, Ministry of Agriculture, Tunis-Port

1. Physical and geographical characteristics of the Tunisian coastal zone

The Northern coast of Tunisia consists of narrow plains some of which are dominated by hilly relief (300-400 m) with higher elevations westwards. This is the most humid part of the country (over 1.000 mm of rainfall). The natural vegetation is represented by evergreen oak, Aleppo and maritime pine. Frequent forest fires (0.5% of land a year) have turned large areas into maquis and garrigue.

The North-Eastern coast is composed of long beaches and the large Medjarah and Tunis plain is separated from the coastline by consolidated or moving sand dunes. The semi-arid climate of this region is characterised by approximately 380-400 mm of rainfall distributed sporadically throughout the year, frequently in the form of rain showers. The prevailing gusty winds are from the northwest. The vegetation of this region is evergreen and typically

Mediterranean (evergreen oak, Aleppo pine, olive tree, thuja and corc oak). The moving dunes have been successfully afforestated with maritime pine and Acacia.

The Cap-bone Peninsula reaches an elevation of 637 m in its central part at which point the terrain slopes towards funnel-shaped plains. The coast is generally rocky, with long beaches, dunes and dry salt lakes in its eastern part. The bioclimate of Cap-bone is similar to that of the Northeastern region.

Sahel consists of a large plain open to the sea in its eastern part with an undulating relief (150 m and more) which develops towards the east and south into a plateau (100 m). This coastline, a mixture of beaches and rocky outcrops, is a semi-arid region of infrequent showers. Annual rainfall ranges between 400 mm in the north and 200 mm in the south. Its aridity is accentuated by high evaporation (700-1000 mm). Clusters of Aleppo pines growing on the hillsides give way to steppes in the south and to halophytes in the depressions.

The Gulf of Gabes is a flatland with dry lakes and lagoons interrupted by isolated hills. The coastline is indented forming a number of small juts and large promontories (Mehabeul, Zarzis). There are also the islands of Jerba and Kerkena. Aridity is here more severe than in the Sahel region (less than 200 mm of rainfall) and evaporation exceeds 2000 mm. Frequent strong winds (16 m/s) blowing over barren degraded steppes are also characteristic of this region.

The northerly, most humid part of the coast and the river valleys are composed of deep fluvisols. Rendzina and cambisol are developed on calcareous rock. Chromic cambisol prevails in the sub-humid northeastern region while the most common soil in the arid part of Sahel is calcic yermosol. Salinisation and sodification frequently occur in the alluvial plains. Deep yermosols with a marked salinisation of soil in depressions have developed in the large plain behind Caussa. In the drier southern part of the coast there are frequent appearances of gypsum crusts.

2. Soil degradation in the Tunisian coastal zone

The coastal zone of Tunisia is affected by all types of soil erosion. Based on the estimates of water erosion intensity (FAO method, 1979), the author states that the Tunisian coast is affected by moderate sheet erosion. Generally, a moderate loss of soil by erosion in the coastal region does not exceed 7 t/ha a year, although in some areas (Cap-bone) it amounts to as much as 60 t/ha.

Wind erosion is particularly marked in the Gulf of Gabes and Jeffara (over 120 t/ha a year). Mild forms of deflation are noticed in the north which is, however, affected by an active accumulation of sea-sand dunes. In other parts of the coastal zone wind erosion is negligible and losses caused by it do not exceed 10 t/ha.

Sea water erosion is important in some areas. In addition to strong winds and the sinking-type coastline, sea erosion has resulted from human activities (construction of dams; destruction of dunes for the construction of tourist facilities; extraction of sand).

Since Tunisian independence, the Government has taken extensive measures to protect the soil. Until 1984, about 105.000 ha were afforested for the protection of land and water; 15.000 ha for the consolidation of dunes; 10.000 ha designated as protective forest belts. Thus the runoff is 20 times less, and losses from erosion are 10 times less. Along with afforestation, other measures have been taken, such as the construction of anti-erosion barriers and small water reservoirs ("meskat").

3. Recultivation of abandoned agricultural lands

In general, there are large areas of abandoned land in Tunisia. However, the reasons for abandoning individual agricultural holdings are the following:

(a) inadaptability of crop raised to the socio-economic level of individual farmers;

(b) fragmentation of agricultural holdings;

(c) abandoning irrigation due to lack of water and secondary salinisation;

An example of the first has been recorded in the southern region where old olive groves cannot yield enough to cover production costs, especially when they rely on ill-maintained water reservoirs. The Government of Tunisia has launched a number of projects to reverse this trend.

The second reason holds good for the northern and northeastern coast, where over 50% of the holdings are smaller than 5 ha. Thus a law is being prepared to establish the lowest possible surface area of holdings and thereby prevent their further fragmentation.

An excessive exploitation of aquifers for irrigation in the northern and northeastern region has caused the piezometric level to drop and has induced soil salinisation. The Tebourba region (Sahel) has been chosen for an experiment on the artificial recharge of aquifers by building weirs.

4. Protection of agricultural land from urban expansion

More than 60% of the Tunisian population lives in the narrow coastal zone, and this unfavourable coast-hinterland distribution of population is steadily increasing.

The increasing pressure of housing development, tourism and industries has led agriculture into a critical situation which calls for the immediate legal protection of agricultural land. For example, areas reserved for urban expansion expanded 5 times over the 1962-1974 period. Such a situation ultimately brought about the enactment of a law (1983) which defined agricultural land, forests, and grazing land, and determined three categories of zones: (a) prohibited zone; (b) protected zone; and (c) zone under special use permit. The first two categories are highly protected and there is little chance of allocating them to uses other than agricultural. All three categories are marked on the map prepared by the Ministry of Agriculture.

5. The need for and possibility of international co-operation

Tunisia could benefit from the experiences gained in the protection of soils by introducing terraces and hedges for crops such as fruits and vegetables to supply the tourist and urban markets. Some types of vines and apples in the northern and the northeastern region are resistant to drought and well adapted to poor eroded soils. Experiences in that type of environment should be compiled and evaluated. The experience of recharging aquifers with used water and their protection against pollution could also be useful.

Along the entire coastline, there are deep but saline soils. It would be useful to know how to desalinate those soils where groundwater is already over-exploited.

The author suggests the regular organisation of regional seminars to deal with the jointly-selected subjects; exchanges of books and publications through the Regional Centre; exchanges of visits with laboratories and centres dealing with soil protection issues with a view to establishing joint project and co-operations.

TURKEY

Author: Dr M.Y. Kilinc, Civil Engineering Department, Middle East Technical University, Ankara

1. Physical and geographical characteristics of the Mediterranean part of the Turkish coastal zone

The Mediterranean part of the coastal zone in Turkey is made up of the provinces of Nathay, Adana, Mersin and Antalia. To the rear of the coastal zone are situated the Torus mountain ranges (altitude 300-4.000 m). Between the mountain slopes and the coastline are the plains the largest of which are Antalia and Adana. Rivers descending from the mountain ridges flow through deep ravines and form large deltas at the estuaries. A large part of the coast belongs to the karst zone. More than 45% of the surface consists of slopes of considerable declivity, which causes various types of soil erosion.

The climate of the coastal zone is typically Mediterranean. In elevated regions, the mean annual precipitation is 1000 mm, and in the lowlands around 600 mm. The rains have a high erosion potential, especially during the winter and spring periods. The average annual temperature is 18°C.

In lower altitude areas the vegetation is composed of maquis and low forests of Quercus coccifera, Pistacia lentiscus, Laurus nobilis, Myrtus communis. In higher altitudes are found Pinus brucia, Abies clicia, Pinus nigra, Cedrus libani, Quercus libani, Juniperus oxycedrus.

Types of soil in the coastal area are not specified in the report.

2. Soil degradation in the Turkish Mediterranean coastal zone

Turkey is in possession of reliable data for the classification of soil uses in respect of all four Mediterranean provinces. They have been used for a precise evaluation of the soil degradation types. A geographical survey of these data shows that the nature and the degree of degradation vary from

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province to province. Water erosion is evidently the predominant type of soil degradation in the Mediterranean coastal zone of Turkey. Salinisation, sodification and swamping are present to a certain degree and, in some regions, wind erosion also occurs. Forest fires are of great intensity. In the period 1950-1980, 1.200.000 ha of forest were destroyed by fire.

The main causes of soil erosion are inadequate land use, overgrazing, forest fires, a high percentage of steep slopes and susceptibility to erosion of the parent substratum. Over a ten-year-long period of effort, Turkey has managed to draw a soil erosion map. On the basis of this map and the land-use maps, systematic soil protection measures are being applied. Five national agencies are in charge of specific aspects of soil erosion, with strictly defined tasks coordinated by the Department of Environment Protection.

During a soil protection campaign (1972-1983) counter-erosion interventions took place on 86.000 ha, 10.700 ha of pasture lands were improved and about 1.000.000 ha of degraded land afforested.

3. Recultivation of abandoned agricultural lands

In the coastal area, good agricultural land is not abandoned. Only those lands that are essentially forest areas converted to arable land are being abandoned. Inappropriate use has resulted in erosion and the destruction of many forest zones. Therefore, the afforestation of those parts with a minimum of productive potential has proved to be the only valid method of recultivation of abandoned land in the coastal area of Turkey.

4. Protection of agricultural land from urban expansion

Urban and industrial expansion at the expense of good agricultural lands is an acute problem in the Mediterranean coastal area in Turkey. The author of the report sees the problem in the lack of appropriate land use classification, as a general classification cannot satisfy this specific purpose. There are also unsolved social problems, as inadequate use and land deterioration are due also to the absence of alternative sources of income.

5. The need for and possibility of international co-operation

Many common issues could be solved by a co-ordination of effort and through the organisation of seminars. One is the problem of the development of erosion forecast models. Universal soil loss equation is applicable only to cultivated land, and involves some difficulties. By a common effort new models should be developed for the evaluation of soil erosion loss, involving the establishing of monitoring.

Turkey has for many years been engaged in evaluating and determining the factors of universal soil loss equation (USLE). In this connection, a project is being proposed namely "Water erosion as a consequence of inadequate land use".

YUGOSLAVIA

Author: B. Milos, Institute of Adriatic Agriculture, Split

1. Physical and geographical characteristics of the Adriatic coastal zone

The coastal zone of Yugoslavia is made up of a large number of islands and the coastal strip between the coastline and the watershed which can be several kilometres wide. The mainland coastline is 2.000 km long while together with the islands the total length of the coast reaches almost 6.000 km.

The Adriatic coast is composed mostly of karstified Mesozoic limestone. In some rock folds tertiary flysch is found (marls, sandstone, conglomerates and limestone). At the foot of larger mountains, accumulated quarternary gravelly deposits occur. In the greater part of the coast high vertical mountain ridges rise above a very narrow coastal strip. Major rivers have opened alluvial plains running to the sea. The Neretva river has developed a wide delta.

Three bioclimatic areas can be discerned in the Adriatic coastal zone; the southern area has the warmest climate with an average annual temperature above 16°C. In the southernmost part, the amount of rainfall is approximately 300 mm while the Dubrovnik area has as much as 1.250 mm a year. In the central zone, the average annual temperature is 15-16°C, and the average rainfall is 800 mm. In the northern area the values range between 13-14°C, and between 800 and 1.400 mm respectively. The distribution of precipitation is typically Mediterranean, with frequent showers sometimes reaching an intensity of 200 mm a day. Very strong winds are typical for the northern area.

The vegetation cover belongs to two zones: (a) the Eumediterranean zone of the evergreen oak with the Olec-Ceratonion sub-zone in the coastal strip and the southern islands, and the Quercion ilicis sub-zone deeper inland; (b) Carpinetu orientalis deciduous zone, which follows the first zone and reaches the Sub-Mediterranean one. Natural vegetation is very degraded so that two thirds of the surface are covered with maquis and garrigue. The vegetation pattern is heavily affected by frequent forest fires.

On karstified limestone, soils such as lithosol, cambisol, luvisol (chromic) are frequent. Rendzina appears on marls, while regosols are characteristic for steeper slopes and mountain peaks. Fluvisols occur in river valleys and in the Neretva river delta, and the saline and alcaline soils are found on drained marine lands.

2. Soil degradation in the coastal zone of Yugoslavia

Karstified limestone is a substratum less vulnerable to water erosion. However, a deep karst erosion is taking place, but until now it has not been studied in detail.

The distribution of precipitation on flysch is essentially different from that on the limestone surfaces. On limestones, 70% of the total precipitation infiltrates into the subsoil, whereas on flysh 52% of water runs off, 24% evaporates, and 24% is infiltrated in the subsoil.

Erosion phenomena have been monitored and recorded on the experimental site at Muc since 1976. The area is typical sandstone and could be incorporated into the regional network of erosion-monitoring stations. The data recorded on the site, together with other measurements carried out in the coastal zone, have shown that the land use method and the state of vegetative cover play a decisive role in the erosion occurrences. However, measures applied so far against soil erosion have not yielded satisfactory results. It seems necessary that additional experimental sites be organised for the monitoring of erosion processes.

3. Recultivation of abandoned agricultural lands

The reasons for the abandonment of farmlands are various. Low productivity of shallow and stony soils and fragmentation of land holdings, expensive labour and little economic effect are the major reasons which have made farming in the coastal region so unattractive. On the other hand, the development of tourism and industry has generated a population drain from the islands marking a population decrease of 8.3% in the period of 1961-1971, and this trend is likely to continue. The worst situation is with olive and vine growing on shallow soils and lithosols. The bulk of these lands is unsuitable for modern cultivation techniques and therefore should be returned to forests - not spontaneously though because growth in these areas does not seem to develop in a satisfactory way. What is necessary is the reclamation with selected species and the application of appropriate silviculture measures. Towards this aim, a special experimental station has been set up where the behaviour of different species of trees in given ecological conditions is being studied. The author suggests this experimental site as an interesting case study of possible interest for other Mediterranean countries.

An excellent example of agriculture on unfavourable soils is the vineyard terracing on lithosols at Primosten.

Recultivation of abandoned lands of high productivity (soils on flysh), with the application of reliable counter-erosion measures, should compensate for the loss of less productive agricultural land.

In addition to this, land reclamation in river valleys can considerably enhance the production capacity. One of the successful land-reclamation projects is the project of the Neretva river delta implemented with the assistance of FAO.

4. Protection of agricultural land from urban expansion

Parts of the Adriatic coast are among the regions with the highest population density in Yugoslavia, having reached (during the period 1961-1971) a rate of growth of 7.6%. The period that followed was marked by an even higher increase due to an abrupt development of tourism in the coastal zone. As the arable land in this area is very scarce, the urban expansion gave rise to serious conflicts between the potential users of land. The town of Split, for example, has taken over the past 10 years about 800 ha of best land. Measures which were to protect fertile land against this kind of loss have unfortunately proved ineffective. However, encouraging new legislation has have been adopted with a view to securing a better protection of the land surrounding large cities. Nevertheless, a high level of government decentralisation does not make the effort any easier.

5. The need for and possibility of international co-operation

The experience and knowledge of the problems pertaining to land protection in the coastal area of Yugoslavia are far from sufficient. Co-operation on the regional level in this field is therefore necessary to speed up the accumulation of necessary knowledge. The author particularly stresses the need for establishing an information system (data bank) as a means for a more efficient co-operation.

Yugoslavia, being a country with large karst areas, can offer its own experience and locations for the instalment of experimental stations with a view to seeking solutions to karst hydrology and ecology problems which are sporadically present in all Mediterranean countries.

3. CONCLUSIONS

"Coastal zone" is taken to mean a strip of land along the coastline which includes coastal plains and the seaward slopes of mountain ranges in the hinterland with their water courses running towards the sea. The borderline of coastal zones defined in this way coincides with the watershed of the coastal basins. In cases where the coastal plain penetrates deep inland, the coastal zone must then be defined by means of another natural border. In northern Africa, for example, the amount of rainfall abruptly drops on leaving the coast towards the hinterland, so that only 50 km from the coastline the Mediterranean climate gives way to a desert environment. The line of this bioclimatic change may, in this case, define the width of the coastal zone. In the case of the Po delta, for example, the reach of the Mediterranean bioclimatic characteristics may be taken as the borderline of the coastal zone.

The geomorphology of the entire Mediterranean coastal zone is marked by a variety and alternation of the following elements:

(a) large river deltas (Po, Rhône, Nile, Neretva);

(b) narrow plains with a mountainous hinterland;

(c) large plains and depressions frequently containing lakes;

(d) hills and mountain ranges touching the coastline;

(e) coastal dunes typical of the eastern Mediterranean.

These geomorphological elements can be found along the entire Mediterranean coastal zone, but in each country it is represented by different mutual relationships.

The common climatic feature of the Mediterranean coast is a concentration of rainfall in the winter months, mostly in the form of rain showers and torrents, which increase the erosion risk in the whole region. With regard to the amount of rainfall it is easy to differentiate the humid western part of the coast from its dry eastern part, which is, in addition to water erosion, affected by wind erosion and soil degradation due to salinisation and sodification. Semi-arid regions are mostly erosion-susceptible Mediterranean areas.

The parent substrates of the Mediterranean coastal zone are very diverse. The most frequent are limestone, marl, volcanic rock and tuff, clastic sediments, various alluvial deposits, bentonite clay, etc.

The national reports have not commented on the applicability of the FAO soil classification. However, since all the authors have used this classification, it can be claimed that its application is possible on the global level of information exchange. It is to be expected that in a detailed project an additional correlation will be needed.

The reports have identified the spread of the following types of soil: lithosol, rendzine, luvisol, chromic luvisol, fluvisol, gleysol, cambisol (both eutric and district), chromic vertisol, regosol, yermosol (calxic, gypsic), solonchak, solonetz, arenosol, xerosol, planosol, rhodo-chromic cambisol, calcaro-chromic cambisol, pheozem.

Water erosion is an acute problem over the entire Mediterranean coastal zone. The major factors which encourage erosion processes are:

- rainfall erosivity;
- high erodibility of some substrata (marl, volcanic tuff, aeolian deposits, and some other loose Pleistocene sediments);
- improper land use;
- inadequate soil cultivation and crop rotation;
- bad forest management;
- frequent forest fires;
- sodification in arid areas reducing the infiltration ability of soil.

Inventories of erosion processes and assessments of erosion risk have been made only in Egypt, Turkey, Libya and Tunisia. Erosion mechanisms in specific Mediterranean conditions have not been fully investigated, nor has modelling of the erosion processes. Therefore, the Israeli experience in this field deserves full attention.

Traditional measures of soil protection from erosion in the region (fortified terraces) are of little account because they still make mechanisation and vehicular transport access impossible. Apart from Italy where extensive experience has been reported in an integrated protection of soils from erosion, other countries of the Mediterranean have only just begun projects which should secure a modern approach to the problems of soil protection.

In arid regions of the Eastern Mediterranean, wind erosion is an acute problem. Data on a systematic research into this phenomenon and measures taken for the protection of soil from deflation and sand accumulation are available from Libya. As possible case studies, the following subjects seem appropriate:

(i) experimental research of erosion mechanism related to soil sodification (Israel);

(ii) making and use of soil erosion maps (Turkey);

(iii) integral solution of the problems pertaining to the protection of soils from erosion (the projects of France, Egypt, Tunisia, Morocco);

(iv) aeolian erosion control (Libya).

In river deltas and sections of the coast which are composed of soft sediments, beach erosion is a serious problem (Egypt, Israel, Tunisia, Italy). Egypt and Israel have gained considerable knowledge and experience in research and in combating the process, making their efforts suitable as a case study in this specific field.

Landslide is a specific problem emphasised by Cyprus, and very probably felt in other countries too. The activities in Cyprus (ongoing international co-operative project) may be suitable as a case study.

Salinisation and sodification of soils is a problem closely related to the rational use of water resources. The main form of secondary salinisation is the increased salinity of subsoil water (aquifers) which is used for irrigation. Aquifers became saline because of their excessive pumping for irrigation and the intrusion of seawater. Solutions are sought in the construction of dams and in the artificial recharge of aquifers from surface reservoirs, as well as in an increased use of reservoir water for irrigation. Some research has been carried out in Tunisia along these lines.

Abandoning of agricultural land is a widespread phenomenon in the Mediterranean throughout history and occurs just as much, if not more, today. The reasons for such a situation are:

- decreasing fertility of soil due to erosion, salinisation, sinking of the coast, etc;
- lack of water for irrigation;
- fragmentation of agricultural holdings below the critical limit of profitability;
- discrepancy between crops raised and the technical and economic requirements of contemporary production;
- submersion of the coastline;
- cultivation on steep slopes inaccessible for mechanisation;
- countryside and forest fires;
- socio-economic reasons generating migration of labour for employment in tourism and industry.

The recultivation of abandoned land is necessary, because in many regions there is a lack of arable land, while abandoned sites have lost their economic and ecological function. Analysing the reasons that led to such a situation in the Mediterranean coastal zone, it may be concluded that reclamation demands an appropriate effort by Governments or by wider social communities, since the problem can be solved only if approached systematically, with large-scale interventions, such as:

- development of large hydrotechnical systems;

- large afforestation projects for low-productivity areas exposed to various risks, which are no longer suitable for agriculture;

- tax and policy measures which will induce farmers to continue with agriculture production.

An example of such efforts can be found in Italy (large-scale afforestation projects), in Egypt (development of large irrigation systems), in Tunisia (regulations controlling fragmentation of holdings and stimulative agricultural policy), in Libya (six major projects), and in Cyprus (the Land Consolidation Law). It is worth underlining that reclamation does not necessarily mean a compulsory restoring of original crops, but is rather a choice of the most appropriate ways of land utilisation, including silviculture. What is indispensable in considering the reclamation issues is a land use suitability classification.

An inequitable distribution of natural resources in some Mediterranean countries has resulted in high concentrations of population in their coastal zone (Egypt, Tunisia, Cyprus), while tourism development, particularly intensified in the last decades, has generated large migration flows towards the coast in all Mediterranean countries. The result of such a trend has been an enormous urban expansion and irreparable loss of hundreds of thousands of hectares of fertile lands. Coupled with the loss of productive land has come a biological and aesthetic degradation of the environment. The acuteness of the problem in some countries (Israel, Tunisia, Egypt, Malta, Libya) encouraged strict regulations to be introduced with a view to controlling and eventually reversing this undesirable process. In this, the following principles may be pointed out:

(i) it is essential to have a central national body responsible for key decisions with control over the implementation of projects where representatives of all relevant interests will be delegated;

(ii) it is necessary to create a single common classification system of land evaluation, which would be the basis for determining the zones and categories of land under various protection regimes;

(iii) first and second category agricultural land must be protected in full from other uses;

(iv) losses of arable land should be compensated by new lands acquired through urban rent.

4. PROPOSALS

From the analysis of national reports and following their suggestions, the following proposals can be formulated:

4.1 PAP/RAC should:

(a) organise a permanent exchange of experience, of books and publications;

(b) organise visits of experts as well as the training of specialists dealing with soil protection;

(c) facilitate transfer of knowledge and experience among Mediterranean countries;

(d) organise co-operative projects, when common problems should be solved by joint efforts;

(e) facilitate co-operation among the countries by means of experts'missions.

4.2 Each Mediterranean country should designate an institution as the focal point and coordinator of activities on soil protection in its own coastal zone.

4.3 A permanent co-operation should be established with FAO which has a large international experience in this field.

4.4 A Workshop for Mediterranean experts should be organised to:

(a) present the case studies suggested in this synthesis report;

(b) consider the possibilities for launching a joint project in the field of the protection of soils from erosion which could incorporate and develop the following elements:

- preparation of a global inventory of erosion phenomena and assessment of erosion risk in Mediterranean coastal zones on a map on a scale of 1:1.000.000 (the FAO method);

- development of a network of stations in the Mediterranean coastal regions, which would study and monitor erosion processes with a view to making a foundation for the development of optimal agrotechnical systems for soil erosion control and protection of the coastal environment;

- selection of locations (installations) where a modern integrated project of the protection of soils from erosion has been applied, using them for demonstration of training courses;

- development of a unique information system which will cover the entire subject matter of the protection of soils from erosion;

- for this project, co-operation and financial support should be sought from international organisations (FAO, EEC, UNDP).

4.5 A document should be prepared containing:

(a) comparative survey of land policies and legislations relevant to land use in urban areas of the Mediterranean coastal zone;

(b) summary of various experiences.

Such a document could be useful to the countries of the Region in creating their own land policies and legislation.

The Workshop (item 4.4) should determine priorities and the workplan for the follow-up activities.

PROMOTION DE LA PROTECTION DU SOL COMME COMPOSANTE ESSENTIELLE DE LA PROTECTION DE L'ENVIRONNEMENT DES ZONES COTIERES MEDITERRANEENNES

Synthèse des rapports nationaux

par

M. CIRIC
Faculté de sylviculture
Sarajevo, Yougoslavie

1. INTRODUCTION

Ce projet de synthèse a été établi sur la base des rapports nationaux émis par les pays méditerranéens participant au projet réalisé par le Centre d'activités régionales pour le Programme d'actions prioritaires du Plan d'action pour la Méditerranée (PAM) du PNUE.

Ont servi de base à l'élaboration de ces rapports nationaux: l'avant-projet et le mandat exposant les principales caractéristiques de la dégradation des sols, fixant les objectifs du projet ainsi que les modalités de sa réalisation.

En esquissant le projet, il a été admis que les sols de la zone littorale de la Méditerranée sont exposés à diverses formes de dégradation dont les principales sont l'érosion, la salinisation et la sodification. Les conditions naturelles de la région méditerranéenne favorisent diverses formes d'érosion du sol et notamment une vulnérabilité de la couverture végétale aux risques d'incendie. Au cours d'une longue période historique, les activités humaines ont constitué un puissant stimulus aux processus de dégradation et ont, assez souvent, abouti à des dommages graves, voire à une perte irréparable de sols de bonne qualité.

Dans les zones arides de la Méditerranée, la salinisation et la sodification peuvent, de temps à autre, mettre hors d'usage de vastes superficies de terre en les désertifiant. Les processus de l'érosion et de la salinisation interagissent sur la bande littorale car le sédiment d'érosion maintient l'équilibre nécessaire dans maintes sections de la côte. Un apport excessif de sédiment menace les écosystèmes aquatiques des zones côtières, tandis qu'un apport réduit amorce une érosion de la bordure littorale qui, dans certaines parties de la région, soustrait de la côte des terres fertiles. D'autre part, l'eau de mer occasionne une salinisation de la couche aquafère et de la végétation côtière.

L'urbanisation intensive de zones côtières, notamment au cours des dernières décennies, a exercé, dans tous les pays méditerranéens, une pression très forte sur les terres arables en raison de l'extension des villes, des zones industrielles et des infrastructures; par son agressivité et son intensité, ce processus a entraîné une perte de terres qui dépasse celle causée par la dégradation, ce qui, de toute évidence, impose encore davantage d'instaurer sans délai la protection du sol dans le cadre général du système productif et socio-économique constitué par la mer, la zone côtière et la population locale.

Bien que divers segments du littoral méditerranéen diffèrent par les conditions naturelles qui y prédominent et par leur niveau de développement, ils sont confrontés en commun au problème crucial de la protection du sol. C'est pourquoi la coopération des pays méditerranéens en matière de protection du sol dans les zones côtières s'est avérée justifiée et nécessaire, incitant les gouvernements de la région à confier au CAR/PAP l'organisation des activités requises à cette fin dans le cadre du Plan d'action pour la Méditerranée.

Conformément aux principes généraux de coopération qui régissent le PAP, il est prévu que le projet fournira et assurera:

- les bases à l'échange d'informations, de connaissances et d'enseignements acquis lors des recherches menées en matière de protection des sols dans les zones côtières de la Méditerranée;

- l'identification d'activités de recherche et d'applications pratiques de pointe en vue d'asseoir la coordination et la complémentarité des diverses entreprises et d'explorer les possibilités de projets communs;

- l'échange d'experts et de stagiaires ainsi que des diverses formes d'assistance technique en matière de recherche scientifique et de mesures de protection des sols.

Au stade actuel du projet, l'accent est mis sur trois problèmes qui se posent avec la même acuité dans presque tous les pays méditerranéens. Ce sont:

- l'érosion des sols dans ses diverses manifestations;

- la mise en valeur des terres productives abandonnées;

- la protection des terres contre l'expansion urbaine et les utilisations non agricoles.

2. RESUME DES RAPPORTS NATIONAUX

ALGERIE

Auteur: Buaem Trabelsi, ministère des Eaux et Forêts et de la Protection de l'Environnement, Kouba, Algérie

1. Traits physiques et géographiques de la zone côtière de l'Algérie

Les bassins versants, orientés vers la mer Méditerranée, occupent en Algérie une superficie totale de 13 millions d'hectares, avec un chiffre total de drainage des eaux égal à 12 milliards de m^3 par an. Le relief se caractérise par des plaines côtières isolées qui sont en général insuffisamment drainées et ont une terre lourde. Les plaines sont séparées de la partie continentale par la chaîne montagneuse de l'Atlas tellien (1000 à 1800 m d'altitude) qui se compose de marnes, d'argiles et de flysh.

Le climat de la zone littorale est de type méditerranéen, avec 600 à 2000 mm de précipitations atmosphériques qui, généralement, augmentent d'ouest en est et se manifestent pendant la période hivernale sous forme d'averses. La

végétation de la partie humide se caractérise par la prépondérance du cèdre, du chêne vert (Quercus ilex), du chêne liège et du pin maritime, tandis que dans la partie semi-aride dominent le pin d'Alep et le genévrier.

2. Dégradation des sols dans la zone côtière de l'Algérie

La topographie du terrain, caractérisée par un pourcentage élevé de versants abrupts et la sensibilité du substrat à l'érosion, rend les écosystèmes très vulnérables à cette dernière. Le processus d'érosion a été amorcé à la suite de la destruction des forêts et d'utilisations du sol où ont prévalu la céréaliculture et le surpâturage, si bien que l'érosion a gagné environ 30% de la superficie totale. L'intensité de l'érosion dans la région humide atteint 16 m^3/ha/an, alors qu'elle est de 30 m^3/ha/an dans la région semi-aride orientale. L'érosion la plus marquée se rencontre dans la zone agro-pâturo-sylvestre qui constitue 52% de la superficie, ainsi que dans la zone purement agricole (qui en constitue 13%), alors qu'elle se manifeste à un faible degré dans la zone forestière (31%).

3. Mise en valeur des terres agricoles abandonnées

Le ministère des Eaux et Forêts et de la Protection de l'Environnement et sa Direction de la protection et de la mise en valeur des sols mènent une lutte contre l'érosion en s'appuyant sur un réseau étendu d'institutions nationales et régionales et sur une législation pertinente. Il convient de remarquer que la stratégie en cause comporte une approche intégrée de la gestion des bassins hydrographiques impliquant une intensification de l'agriculture assortie de la protection et de la revalorisation des sols et des ressources en eau ainsi que la promotion du statut socio-économique des exploitants agricoles. Le reboisement revêt une importance particulière pour la protection des sols au sein de ce programme; il a été réalisé sur environ 250.000 ha au cours de la période 1980-1984, et les mesures de protection des sols ont porté sur 51.000 ha.

Des recherches expérimentales sont en cours en vue de mieux connaître le mécanisme de l'érosion et celui du transfert du matériel d'érosion ainsi que de mettre au point des mesures anti-érosion. Tel est le cas du projet pilote "Mina" qui doit servir de modèle pour l'élaboration d'une stratégie nationale en matière de gestion des zones hydrographiques de l'Algérie à l'aide d'une approche intégrée. Il convient aussi, à cet égard, de souligner l'importance des recherches menées de concert par les trois pays du Maghreb (bassin fluvial de l'Isser) qui doivent permettre la mise au point d'un modèle de simulation du transfert des sédiments dus à l'érosion et à promouvoir une méthodologie générale de levé de terrain, d'observation et de traitement des données. La station expérimentale d'Ouzera est dotée de parcelles expérimentales pour la mesure de l'érosion due à divers traitements du sol. L'ensemble des projets de recherche en question comportera aussi des expériences avec un simulateur de pluie.

De vastes surfaces de l'Algérie (environ 375.000 ha) ont été assujetties à des mesures de lutte contre l'érosion.

4. Protection des terres agricoles contre l'expansion urbaine

Bien que l'Algérie soit démunie de terres agricoles, on enregistre une tendance à la progression de l'expansion des zones urbaines et industrielles au détriment des terres agricoles exploitables. Ce phénomène a entraîné, depuis 1962, la perte de 70.000 ha. Des mesures de protection des terres agricoles ont été édictées en 1974, et un programme à long terme de mise en

valeur des sols des régions montagneuses est actuellement en cours d'exécution afin d'arrêter l'exode rural de ces régions vers les villes de la zone côtière.

5. Besoins et possibilités en matière de coopération internationale

L'auteur souligne l'importance de l'établissement d'une carte de l'érosion à l'échelle 1/200.000, en coopération avec les pays méditerranéens et grâce au CAR/PAP. Pour la réalisation dudit projet, il est nécessaire d'identifier et de décrire les terrains homogènes à l'aide des photographies aériennes et par satellite, de développer un réseau d'acquisition de données, d'établir une méthode de levés de terrain et d'admettre une légende commune.

L'Algérie est désireuse de bénéficier du savoir-faire et des enseignements concernant la mise en valeur des pâturages, les méthodes d'évaluation de l'aptitude des sols dans les bassins versants et l'oeuvre législative en matière de protection des sols. L'appui accordé à l'Institut algérien de recherches forestières et notamment la fourniture d'un simulateur de pluie constitueraient une contribution très précieuse aux travaux menés dans ce pays dans le domaine de la protection des terres.

En revanche, l'Algérie peut faire bénéficier d'autres pays de l'expérience qu'elle a elle-même acquise lors de l'exécution de plusieurs projets importants, surtout en ce qui concerne la gestion des bassins versants fondée sur une approche intégrée.

CHYPRE

Auteur: S. Pissaridès, ministère de l'Agriculture et des Ressources Naturelles, Nicosie.

1. Traits physiques et géographiques de la zone côtière de Chypre

Le long de la partie septentrionale de l'île s'étend la chaîne montagneuse calcaire de Kyrénia (1.000 m) et dans la partie centrale se trouve le massif du Troodos (2.000 m) constitué de roches ignées. Entre ces deux régions montagneuses s'étend la vaste plaine de Messoria en direction de la côte. La partie restante de la côte se compose d'une étroite bande de plaines (2 à 10 km) qui, au nord s'élève de manière abrupte pour s'unir à la chaîne de Kyrénia. Une région au relief valloné s'étend entre les plaines côtières et le massif du Troodos (dans les parties méridionale et occidentale de la côte).

Le climat de l'île est de type méditerranéen avec des hivers tempérés et pluvieux (en décembre, on enregistre une température moyenne de 9°) et des étés chauds et secs (35° en moyenne en août). La moyenne annuelle des précipitations est d'environ 500 mm, très souvent sous forme d'averses brèves et violentes. On assiste à des sécheresses modérées tous les trois ans et très marquées tous les 10 ans.

La végétation naturelle se compose de cyprès (*Cupressus sempervirens*) dans la chaîne montagneuse de Kyrénia. Le pin noir (*Pinus nigra*), ainsi que le genévrier (*Juniperus foetidissima*) et le cèdre (*Cedrus brevifolia*) dominent dans le massif du Troodos. Le pin d'Alep constitue la principale espèce forestière et croît partout à des altitudes inférieures à 1.500 m; il représente 90% de la réserve en croissance. Les forêts dévastées sont remplacées par des types de maquis représentés par le chêne (*Quercus brevifolia*), le fraisier (*Arbutus andrachue*), l'olivier (*Olea europaea*), le

térébinthe (Pistacia terebinthis) et le caroubier (Ceratonia siliqua). La couverture de garrigue se compose abondamment d'espèces telles que le lentisque (Pistacia lentiscus), le myrte (Myrtus communis), etc. Parmi les cultures de zones agricoles (en majeure partie le long du littoral), on trouve principalement les céréales, la vigne, l'olivier et le caroubier.

Le rapport contient une carte des sols de la zone côtière qui est contrôlée par les pouvoirs publics (296 km). Sur la superficie totale de 1216,8 km^2 qui relève de ce contrôle, approximativement 21% sont constitués par des plaines côtières. La vaste plaine comprise entre Famagouste et Larnaca est un plateau (60 m au-dessus du niveau de la mer) de roche calcaire et de cambisol rhodo-chromique (d'après la classification FAO), qui a subi des modifications considérables dues à une forte influence humaine.

Au nord-est de la plaine, il y a des sols plus profonds classés comme cambisols eutriques. La partie orientale de la plaine côtière de Larnaca est sous l'influence d'une nappe phréatique élevée et saline qui favorise la formation de solonetz et de solontchak. La partie méridionale et occidentale de la côte chypriote est formée d'une étroite bande de terre se composant principalement de cambisols calcaro-chromiques coupés par des collines qui, par endroits, descendent jusqu'à la mer. Celles-ci sont surtout constituées de rendzines et de lithosols calciques développés sur des roches-mères calcaires ou de lithosols eutriques développés sur des roches ignées. Le segment sud de la côte comprend la plaine alluviale. La presqu'île d'Akrotiri renferme un lac salé entouré de sols saumâtres et sodiques. Les cours d'eau dévalent parallèlement les versants des montagnes jusqu'à la mer. Les sols prédominants de ces régions sont des régosols calcaires et des sols de caractères vertiques.

2. Dégradation des sols dans la zone côtière de Chypre

La violence des chutes de pluie, la vulnérabilité érosive des roches-mères, les cultures des pentes abruptes, les incendies de forêt fréquents et le morcellement excessif des exploitations agricoles sont les facteurs qui contribuent à l'érosion du sol à Chypre.

Dans la zone de Larnaca, le 15 juin 1981, une averse d'une durée de 4 heures a été enregistrée (192 mm); elle a occasionné une perte de sol due à l'érosion 25 fois plus élevée que sur l'ensemble de la période de pluie 1980-1981.

L'estimation du taux annuel d'érosion se répartissait de la façon suivante en 1951, selon le type de sol: 612 m^3/km^2 dans les vignobles, 448 m^3/km^2 dans les labours, 339 dans les zones forestières clairsemées et environ 77 dans les zones forestières denses. Ces données prouvent que la végétation et l'utilisation de terres sont des facteurs déterminants dans les processus d'érosion; la déclivité plus accentuée des bassins hydrographiques a eu presque le même impact sur le degré d'érosion.

Charge annuelle de sédiment selon la pente du bassin versant

Pente du bassin	Charge annuelle de sédiment (m^3/km^2)
Pente très abrupte	400 - 600
Pente moyenne (4-8%)	250 - 400
Pente légère (2,5-4%)	150 - 250
Pente minime (1-2,5%)	50 - 150

Des investigations approfondies ont débuté en 1980 en coopération avec l'Institut fédéral de géoscience de la République fédérale d'Allemagne; elles se fondaient sur les critères suivants:

- A Chypre, la pénurie de terre fertile impose de mettre en oeuvre la protection du sol. Dans ce contexte, une collecte systématique de données sur les pertes de sol constitue une base essentielle pour la mise au point de méthodes de gestion appropriées.

- En tant que pays typique de la Méditerranée orientale par son sol et son climat, dotée en outre d'un réseau bien équipé de stations météorologiques, l'île de Chypre peut s'avérer un terrain de choix pour étudier les processus d'érosion par la méthode de Wischmeirer (détermination du facteur d'érosivité "R").

- Plusieurs stations météorologiques couvrent divers substrats géologiques et garantissent une évaluation correcte de l'érodabilité respective de divers substrats typiques de la région méditerranéenne. Les résultats obtenus indiquent que les marnes sont les plus érodables, alors que les éboulements de terrain se produisent le plus fréquemment dans les zones d'argiles bentonitiques de Mamonia. Le phénomène d'éboulement fait l'objet de recherches menées en coopération avec le Service britannique de géologie et qui pourraient constituer une étude de cas intéressante pour d'autres pays méditerranéens.

La salinisation secondaire et la sodification des sols de la zone côtière de Chypre sont dues à l'utilisation des eaux saumâtres souterraines dont la qualité s'altère en raison du pompage excessif de la nappe phréatique. Une surveillance continue du phénomène a permis de constater une baisse du niveau de la nappe phréatique de 7 mètres en dix ans (Messaoria) par suite d'un dépassement de la norme de pompage de 20 mln m3 par an. Il s'ensuit que l'eau de mer s'introduit dans toutes les principales couches aquifères de la zone. C'est pourquoi des règlements très stricts sont entrés en vigueur à Chypre pour limiter le pompage des eaux et ils ont suscité des travaux de recherche intensifs visant à une utilisation accrue des eaux superficielles aux fins de l'irrigation.

3. <u>Mise en valeur des terres agricoles abandonnées</u>

La baisse de la fertilité des sols provoquée par l'érosion, un relief défavorable, la rareté de l'eau et le morcellement des exploitations agricoles en dessous du seuil critique de rentabilité ont été les causes principales de l'abandon des terres (environ 13,5% des terres sont classées comme abandonnées).

Chypre est divisée en 24 régions agro-économiques dont chacune est confrontée à des problèmes spécifiques. Par exemple, l'exode rural des régions riches en caroubiers et oliviers est surtout dû à la productivité insuffisante, à la rareté de la main d'oeuvre et à la survenue fréquente d'incendies. Les vignobles sont en butte à l'inaccessibilité des versants aux techniques modernes d'exploitation, à la destruction des terrasses. Il a été décidé que la viticulture devrait être organisée sur des sites plus propices, les vignobles abandonnés étant affectés au reboisement. Dans les zones forestières, les incendies restent à Chypre le problème no 1 du fait que le reboisement naturel est un phénomène très lent et qu'il convient de recourir à des repeuplements forestiers assortis de mesures préventives contre les incendies et l'érosion.

Le gouvernement chypriote a promulgué une loi de remembrement des terres dont on escompte qu'elle réduira tous les effets négatifs qui s'exercent sur le développement de l'agriculture et qu'elle garantira une mise en valeur optimale des terres agricoles.

4. Protection des terres agricoles contre l'expansion urbaine

Une expansion urbaine très brutale s'est produite à Chypre, au cours des dix dernières années, sur la ceinture littorale. Les principales villes, et notamment Limassol, ont accueilli de forts afflux de population. A Limassol, les capacités touristiques représentaient en 1973 15% de celles de l'ensemble du littoral. En 1978, ce chiffre avait atteint 50%. Cet essor démographique spectaculaire a eu pour effet d'entraîner une urbanisation linéaire de la côte. La même situation prévaut dans les zones côtières de Larnaca, Paphos et autres où les terres fertiles laissent place à des usages non agricoles.

Pour prévenir ces tendances néfastes du développement et protéger les ressources nationales, le gouvernement a promulgué la loi sur l'urbanisme et l'aménagement du territoire. Elle comprend des dispositions prévoyant un ensemble d'utilisations du sol pour les zones d'habitation, les zones à protéger, les zones agricoles et les zones industrielles. Elle fixe également des limites à l'alimentation en eau de nombreux établissements des zones côtières, mettant ainsi fin, indirectement, à l'empiètement sur les terres agricoles.

5. Besoins et possibilités en matière de coopération internationale

Toute une série de projets mentionnés dans le rapport peuvent avoir une portée règionale plus vaste (Méditerranée orientale). En se fondant sur ces données, les institutions spécialisées devraient forger une doctrine et mettre en oeuvre des projets pilotes ou implanter un réseau coopératif de recherche et de sites de démonstration. L'auteur estime que l'on devrait attacher une haute priorité au développement de la coopération en matière de salinisation/sodification et de protection des meilleurs sols agricoles contre les utilisations non agricoles.

EGYPTE

Auteur: Prof. Dr. A.M. Balba, Ecole d'Agronomie, Alexandrie, Egypte

1. Traits physiques et géographiques de la zone côtière de l'Egypte

La côte méditerranéenne de l'Egypte s'étend sur environ 1.000 km. Elle comprend trois régions géomorphologiques principales: (a) la région occidentale comprise entre El-Saloum et Alexandrie (environ 550 km); (b) la région intermédiaire comprise entre Alexandrie et Port-Saïd (400 km); et (c) la zone du Sinaï, entre Port-Saïd et Rafah (200 km).

La bande littorale occidentale a 10 à 13 km de largeur. Sa topographie est caractérisée par une succession de crêtes et de dépressions (autrement dit de dunes consolidées séparées par des enfoncements) dont l'axe est parallèle à la côte. Le substrat géologique est principalement composé de formations calcaires pliocènes et pleistocènes couvertes par divers types de sédiments récents.

La géomorphologie de la région intermédiaire est caractérisée par des lacs et un pays plat, ainsi que par la plaine alluviale du Nil, des plaines côtières et des dunes de sable. Les intervalles entre les lacs et les dépressions séparant les dunes se caractérisent par un niveau hydrostatique peu profond.

La région du Sinaï est un plateau en pente inclinée vers la côte et la mer Méditerranée. On peut la diviser en trois zones bien distinctes dont celles situées à l'ouest sont plates et deviennent uligineuses pendant la saison des pluies et salées pendant la saison sèche. Derrière ce pays plat s'étendent des dunes au relief légèrement ondulant qui se situent à l'est, plus près de la côte. Ces dunes sont en partie mobiles. Cette région comprend un certain nombre de bassins de drainage alimentés par les eaux provenant du plateau central du Sinaï. La vallée de Wadi El-Arich (1 à 3 km au large), avec ses hautes dunes de sable, constitue la partie centrale de la région du Sinaï. Au milieu des dunes se trouve la plaine d'El-Shiha dont la surface marquée par l'érosion forme des ravinements. Plus loin, à l'est, une zone de dunes de sable s'étend à la fois dans la partie côtière et la partie désertique de la région. A l'extrême limite orientale, des zones sableuses et ondulantes donnent lieu pourtant à des cultures.

Le climat du littoral méditerranéen de l'Egypte est aride avec une pluviométrie de 90-180 mm dans la région occidentale et d'environ 74 mm dans la région centrale, tandis que dans la région orientale elle passe progressivement de 97 mm à El-Arich jusqu'à 223 mm à Rafah. La quantité des pluies chute brutalement à l'intérieur, si bien que le désert commence déjà à 50 km de la côte.

Les pluies tombent dans la période comprise entre septembre et mars, le plus souvent sous forme d'orages donnant naissance à des torrents. La moyenne annuelle des températures varie entre 23,9 et 26,9°C, et l'humidité relative de l'air est d'environ 70% mais peut tomber à un niveau aussi faible que 10% dans la période comprise entre mars et mai. Les taux d'évaporation sont élevés, notamment en été (3,9-7,9 mm/jour). En raison de l'aridité du climat, la végétation naturelle clairsemée ne peut jouer un rôle important pour favoriser la stabilité de l'écosystème.

Les sols des régions orientale et occidentale sont des solontchaks calciques, ochriques (apparaissant comme la phase saline des sols sus-mentionnés), des yermosols gypseux (renfermant par endroits des couches de gypse dur), des lithosols (sur des zones surélevées de roche calcaire et dans les terres basses érodées) et des arénosols (caractéristiques des dunes de sable). Dans la région de lits de lac à sec il y a des sols sablonneux d'une texture plus grossière avec de fréquentes couches de gypse. Dans la région intermédiaire de dunes basses, le sol est constitué de sable fin, riche en $CaCO_3$. Au sud, le sol est constitué de sédiments fluviomarins, avec des sols salins et sodiques. Une vaste superficie de ce territoire a été drainée, dessalée et irriguée par les eaux du Nil; elle est désormais cultivée.

2. Dégradation des sols dans la zone côtière de l'Egypte

L'érosion hydrique est due à un indice pluviométrique élevé (500), selon les estimations effectuées par la FAO (1979). Il en résulte un ruissellement important et une érosion ravinée qui est particulièrement prononcée sur les substrats de la vallée d'El-Arich. L'érosion en nappe est également étendue, notamment aux sites où la végétation est peu abondante.

L'érosion éolienne touche de vastes zones de sables mouvants avec un indice d'érosion égal à 150 (classification FAO) dans la région occidentale, et variant de 50 à 100 dans les deux autres régions. 50% de la vitesse du vent, approximativement, dépasse les 20 km/h, et c'est pourquoi l'érosion éolienne constitue en Egypte un problème d'une grande acuité.

L'érosion marine de la bordure littorale a commencé à se manifester surtout aprés la construction du barrage d'Assouan qui a interrompu l'apport annuel de 70 à 80 millions de tonnes de sédiments dans le delta du Nil et perturbé ainsi l'équilibre existant entre l'érosion par l'eau de mer et l'apport de sédiments de l'intérieur. C'est ainsi qu'on a enregistré une érosion très marquée de la bordure littorale qui a reculé de 70 à 80 m en profondeur entre 1964 et 1970, et d'environ 180 m entre 1970 et 1982.

L'étude et la surveillance continue du processus sont en cours, et les pouvoirs publics ont chargé une organisation spéciale de l'exécution de projets relatifs à l'édification de murs de protection de la côte. Il s'agit là d'un ouvrage d'une grande ampleur qui pourrait servir d'étude de cas pour le transfert de savoir-faire et l'échange d'enseignements avec d'autres pays méditerranéens.

3. Mise en valeur des terres agricoles abandonnées

La côte égyptienne ayant été peuplée dès les temps historiques les plus reculés, les terres servaient à l'agriculture et au pâturage. Elle a commencé à se dépeupler quand il s'est produit un affaissement de quelque deux mètres au 10e siècle de notre ère et ce phénomène a été aggravé par la fréquence des guerres et des invasions. Dans les années 1850-1952, les régions orientale et occidentale n'ont pas bénéficié de l'essor économique du fait que les eaux du Nil ne permettaient pas, par leur niveau, d'irriguer l'arrière-pays plus élevé et du reste fort peu peuplé, soumis en outre à une intense érosion éolienne. La mise en valeur de ces deux régions est devenue d'autant plus impérative que la densité de la population a atteint 2000 habitants au km^2 dans le delta du Nil. Depuis 1960, une vive attention a été portée à cette question dans la région occidentale, puis dans la région du Sinaï quand celle-ci a été restituée à l'Egypte en 1983.

Deux stratégies de mise en valeur des terres ont été envisagées. L'une consiste, dans la partie occidentale, à introduire les eaux du Nil dans la bande littorale longue de 150 km afin de les faire servir à l'irrigation. Des priorités ont été assignées à la mise en valeur des terres arables en se fondant sur un classement des terres établi par Balba et El-Gabaly en 1967.

Dans la partie orientale, l'autre stratégie consiste en la culture sèche avec pour principales productions les dates, les figues et les olives.

La salinisation et la sodification des zones côtières contiguës à la mer sont un phénomène très répandu en Egypte, notamment au voisinage des lacs, lagunes et marais. Comme il est lié à l'irrigation, il doit être pris en compte comme un facteur important dans la mise en valeur des terres nécessitant l'irrigation.

4. Protection des terres agricoles contre l'expansion urbaine

Le problème de la protection des terres agricoles productives contre l'expansion urbaine se pose avec une acuité toute particulière en Egypte. La plus forte pression sur les terres agricoles s'exerce dans le delta du Nil où l'on relève les concentrations démographiques les plus élevées et où la quasi totalité de la terre est extrêmement productive. Ainsi, l'expansion urbaine ne peut se faire qu'au détriment de cette dernière. De plus, le secteur industriel de la briqueterie repose désormais sur l'exploitation des couches superficielles de sols argileux cultivés (jusqu'à une profondeur de 20 à 100 m), si bien que le niveau de la nappe phréatique se rapproche de la surface.

Bien que le gouvernement ait promulgué et mis en application une législation très stricte pour protéger la terre agricole en subordonnant toute utilisation non agricole dans la vallée du Nil à une décision préalable du ministre de l'Agriculture, on ne peut en escompter des effets appréciables que seulement lorsque des superficies étendues à l'extérieur du delta auront été mises en valeur.

5. Besoins et possibilités en matière de coopération internationale

Le bilan obtenu par l'Egypte dans le domaine des techniques de culture sèche semble restreint, et il incombe absolument de développer la production agricole sur les zones qui peuvent tirer parti des faibles précipitations atmosphériques. Autrement dit, il convient d'optimiser l'utilisation des pluies qui se produisent, de maîtriser le ruissellement des eaux de surface et les réserves en eaux de surface. Comme ce n'est pas là une tache facile, l'Egypte a besoin de l'aide internationale pour implanter un réseau de stations de surveillance continue et mettre au point des méthodes pour réaliser celle-ci, pour mener à bien des études hydrologiques dans des zones spéciales, et pour former des spécialistes nationaux.

L'école d'Agronomie d'Alexandrie est en train d'élaborer, avec le concours d'universités américaines, un projet conjoint complexe intégrant la recherche appliquée et la protection des ressources. Ce projet prévoit une composante formation et l'échange d'enseignements avec des institutions internationales compétentes.

L'auteur du rapport suggère que l'échange d'enseignements entre pays méditerranéens pourrait s'effectuer grâce à l'échange de publications, revues et documentation, à des réunions d'experts et à l'organisation de séminaires communs, à des échanges d'étudiants de premier ou second cycle universitaire.

FRANCE

Auteur: M.F. Fournier

1. Traits physiques et géographiques de la zone côtière méditerranéenne de la France

La zone côtière méditerranéenne de la France forme une étroite bande littorale adossée à l'intérieur aux versants des Alpes, des Pyrénées et du Massif Central. La partie principale en est constituée par la vallée du Rhône et les plaines attenantes à l'ouest (moins de 100 m au-dessus du niveau de la

mer) dans la région du Languedoc. Entre Marseille et Nice, la bande littorale est très rétrécie, flanquée par les contreforts calcaires et silicieux des Préalpes.

Le climat est de type méditerranéen, avec des étés chauds et secs, des automnes et hivers pluvieux. La pluviométrie varie de 500 à 700 mm dans la partie occidentale de la zone, et d'environ 700 à 1.000 mm dans la partie orientale. La moyenne annuelle des températures se situe au-dessus de 14°C.

Le chêne vert, le caroubier, le pin d'Alep, le citronnier, l'oranger et l'olivier prédominent, avec la vigne, parmi la végétation de la région.

Les rendzines et les lithosols sont associés dans les zones calcaires des versants (pente supérieure à 8%), alors que les luvisols chromiques (sols rouges) sont typiques du relief valloné en bordure de la côte. Les sols bruns districues et eutriques dominent à l'ouest de Toulon, tandis que les fluvisols apparaissent dans les terres basses de la côte (Languedoc) et l'on rencontre un sol hydromorphe dans le delta du Rhône.

2. <u>Dégradation des sols dans la zone côtière méditerranéenne de la France</u>

L'auteur souligne les trois faits majeurs dont on doit tenir compte pour comprendre la situation qui prévaut en Méditerranée.

(a) Le climat sec de l'été réduit le rôle protecteur de la couverture végétale, tandis que les pluies torrentielles ont tendance à aggraver les risques d'érosion. C'est pourquoi les formes traditionnelles d'agriculture comportent diverses méthodes de protection des sols, la plus importante étant la culture en terrasses. L'adaptation de ces méthodes aux conditions économiques et techniques actuelles pose un problème délicat.

(b) Jusqu'à un certain point, l'humidité favorise le développement de la végétation et entrave le ruissellement, mais au-delà de ce point elle provoque un mouvement des sols sur le substrat des marnes dont la maîtrise est d'une grande importance.

(c) L'érosion et l'état de la végétation qui en résulte exercent un effet très marqué sur la dégradation des sols.

Bien que les processus et les mécanismes de l'érosion aient fait l'objet, en France, d'études approfondies, la zone méditerranéenne a plutôt été négligée à cet égard. D'autre part, il est difficile de se reposer sur les enseignements du passé puisque les évolutions intervenues au siècle dernier dans l'agriculture ne pouvaient tenir compte des préoccupations de protection du sol. Mais les nouvelles exigences du développement de l'agriculture ont souligné l'acuité des problèmes posés par l'érosion et les autres formes de dégradation. Dans la revue "Forêt méditerranéenne" (Volume II, No 1, 1980), M. G. Duclos a exposé sa méthode d'évaluation des sols sur les terrains en pente qui peut être appliquée à diverses situations de la Méditerranée centrale. Il a insisté sur quatre facteurs dont on doit tenir compte dans l'aménagement des sols pour obtenir un degré maximal de protection (pente, substrat, profondeur du sol, texture et fertilité potentielle des diverses couches, chimie du sol, risque d'érosion et autres propriétés spécifiques). Dans la même revue, M. J.N. Le Houréou examine l'impact des activités humaines sur les forêts méditerranéennes et dans quelle mesure leur dégradation retentit sur l'érosion

et la sédimentation. Ces exemples illustrent que les publications scientifiques ont amplement traité des problèmes de la protection des sols en Méditerranée bien que ces connaissances n'aient pas été confrontées et concrétisées sous forme de projets.

Le premier projet sur l'érosion de la terre arable dans la région du Languedoc est en cours, et il pourrait servir d'exemple de la façon dont le problème de la protection du sol a été abordé sur le littoral méditerranéen français. Les raisons ayant incité à lancer ce projet sont les suivantes:

- monoculture de la vigne avec une technique agricole uniforme et sans qu'on ait cherché à adapter celle-ci aux diverses conditions locales d'habitat;

- insuffisance de la régénération naturelle (organique) du vignoble;

- absence d'un type de culture approprié, ce qui est une pratique fréquente dans le vignoble;

- suppression des murets de soutènement des terrasses et abattage des arbres pour faciliter la mécanisation, ce qui a pour effet de favoriser les processus d'érosion;

- efforts visant à introduire diverses cultures;

- restructuration des terres menée sans tenir compte des impacts écologiques et géomorphologiques.

3. Mise en valeur des terres agricoles abandonnées

L'auteur n'a pas particulièrement insisté sur ce problème, mais on peut déduire de son exposé que la mise en valeur des vignobles abandonnés en terrasses est un problème sérieux en France et qui est traité dans le cadre du projet mentionné au paragraphe précédent.

4. Protection des terres agricoles contre l'expansion urbaine.

Ce problème n'est pas examiné dans le rapport.

5. Besoins et possibilités en matière de coopération internationale

Le projet examiné se prête à la coopération internationale conformément à l'approche intégrée exposée dans le document du PAP No PA-8/ME/5102-83-05. En effet, il vise dans un premier temps à recueillir, classer et diffuser les données et les documents les plus pertinents pour l'identification des problèmes, puis à explorer les causes des phénomènes et à cerner les remèdes, y compris les facteurs de protection. Enfin, il vise à élaborer et proposer des actions d'après les enseignements acquis en France ou ailleurs, ainsi qu'à former des experts pour encadrer l'exécution du projet à l'avenir.

ISRAEL

Auteurs: R. Keren et B. Yaron, Centre de recherches agronomiques, Beth Dagan, Israël.

1. Traits physiques et géographiques de la zone côtière d'Israël

Israël est divisé d'ouest en est, en plusieurs régions physiographiques-lithographiques parallèles: (a) une plaine côtière vallonnée avec des sédiments sableux à l'ouest et des dépôts éoliens à texture fine à l'est; (b) une région montagneuse centrale de roches se composant principalement de calcaires, de dolomites, de craies et de marnes; et (c) un fossé tectonique (graben) oriental comportant divers sédiments alluviaux et carbonates lacustres.

La plaine côtière d'Israël se caractérise par un climat méditerranéen. Les précipitations diminuent en général du nord au sud, passant de 800 à 200 mm; elles varient également en fonction de l'orographie et de l'exposition. L'intensité des pluies peut être très élevée (jusqu'à 500 mm en l'espace de quelques jours). La moyenne annuelle des températures est comprise entre 17 et 21°C.

La végétation naturelle se compose principalement de forêts et arbustes xérophiles dans les zones semi-humides, et d'herbes xérophiles dans les zones arides. La région tropicale à chutes de pluie estivales se caractérise par une haute savane.

Divers sols vertiques prédominent dans la plaine côtière; ils confluent avec des planosols sur les versants à pentes modérées des zones semi-humides ou avec des solontchaks et des solonetz dans la région aride. Les fluvisols se limitent aux plaines alluviales. Au pied des versants dominent les luvisols chromiques et bruniques, dans les hautes terres ce sont les lithosols, tandis qu'on trouve des rendzines sur les formations calcaires. Les phéozems et les cambisols eutriques sont développés dans les zones au climat plus froid.

2. Dégradation des sols dans la zone côtière d'Israël

Dans la région semi-aride, le couvert végétal naturel est clairsemé, si bien que les processus naturels d'érosion sont plus marqués que dans les zones semi-humides. D'une façon générale, l'érosion a laissé des marques visibles sur la genèse et le paysage d'Israël. L'impact des activités humaines sur l'érosion due aux eaux s'est fait sentir de manière durable et prononcée tout au long de l'histoire. Cependant, l'auteur soutient que le risque d'érosion est beaucoup plus grand aujourd'hui que par le passé du fait qu'il est aggravé par l'introduction des techniques agricoles modernes (par exemple, l'application d'herbicides dépouille la surface du sol de sa végétation tandis que les machines lourdes réduisent le taux d'infiltration des eaux dans le sol et favorisent ainsi le ruissellement superficiel). Le coton, principale culture en Israël, laisse les champs à nu et les expose ainsi au ruissellement pendant l'hiver, période pendant laquelle les chutes de pluie sont les plus abondantes (30 à 50% du total annuel).

Les recherches intensives menées en Israël ont confirmé que la diminution du taux d'infiltration dans les sols résulte principalement de la formation d'une croûte superficielle dense due à l'action du sodium échangeable. La

concentration des électrolytes dans l'eau du sol peut jouer un rôle modérateur (plus la concentration des électrolytes croît et plus croît le taux d'infiltration). La notion selon laquelle l'ion Na^+ absorbé joue le rôle déterminant dans la formation de la croûte superficielle et constitue de la sorte un facteur majeur d'érosion dans les zones arides a conduit à privilégier le traitement du sol par le gypse comme moyen de lutte contre l'érosion. L'étude de ces processus revêt en Israël une importance régionale plus vaste et concerne tous les sols arides de composition argileuse en Méditerranée.

Conjointement aux études expérimentales menées dans le désert du Néguev et la plaine de Pleshet, ces recherches pourraient être présentées comme une étude de cas.

Dans la partie centrale de la zone côtière (région de Sharon), l'érosion de la côte (plage) est très marquée et provoque un recul de la bordure littorale à raison d'environ 1 mètre par an. L'érosion des falaises côtières a été due, dans une large mesure, aux activités humaines (drainage incontrôlé du ruissellement urbain, construction de réservoirs d'eau à proximité desdites falaises à potentiel érodable, construction de résidences sur le bord de mer). Il existe un plan national d'aménagement qui réglemente rigoureusement les constructions sur les segments de la côte touchés par l'érosion; il prévoit notamment l'érection de murs de protection.

3. Mise en valeur des terres agricoles abandonnées

Se problème n'a pas été examiné dans le rapport.

4. Protection des terres agricoles contre l'expansion urbaine

Sur la superficie totale d'Israël (soit environ 2 millions d'hectares), 550.000 hectares seulement sont cultivables, dont 130.000 environ dans la zone côtière où se concentre la moitié de la population du pays. Au cours des dernières années, l'industrialisation et l'urbanisation accélérées ont entraîné la perte d'espaces verts qui ont été remplacés par des zones industrielles et urbaines aux conditions biologiques dégradées, des spoliations imputables aux technologies nouvelles, une pollution terrestre, aquatique et atmosphérique.

Près de 94% du territoire d'Israël relève de la responsabilité de l'ILA (Administration foncière d'Israël). Cette organisation a émis des règlements qui accordent la priorité aux terres agricoles. En vertu de la loi sur l'aménagement du territoire de 1965, il a été créé un Comité chargé de la protection des terres agricoles. Parmi les onze membres qui le constituent, plusieurs sont directement ou indirectement concernés par ce problème. La vente ou le morcellement de parcelles agricoles sont interdits; seule la location à bail est autorisée. C'est l'ILA qui statue sur la conversion d'une utilisation agricole en utilisation urbaine.

Les exploitations agricoles coopératives représentent la forme prédominante de production agricole; de la sorte, l'intérêt collectif peut plus efficacement s'opposer aux pertes de terres agricoles.

5. Besoins et possibilités en matière de coopération internationale

Les études approfondies des processus d'érosion dans des conditions bien précises de sodification des sols peuvent avoir une portée plus générale pour d'autres régions arides de la Méditerranée. C'est pourquoi les auteurs proposent que celles-ci servent d'étude de démonstration. En outre, Israël a mis au point un système de simulation de pluie qui est essentiel pour étudier

les mécanismes d'érosion. En soulignant les remarquables propriétés de ce simulateur, les auteurs recommandent de l'appliquer dans d'autres pays méditerranéens.

ITALIE

Auteur: F. Mancini, Institut de géologie appliquée, Ecole d'Agronomie, Florence, Italie

1. Traits physiques et géographiques de la zone côtière de l'Italie

La côte italienne est longue d'environ 9.000 km et elle présente une grande diversité géographique. La section de la côte comprise entre la frontière française et l'embouchure du Magra (dite côte Ligure) est rocheuse. Les côtes voisines de Toscane et du Latium se caractérisent par plusieurs plaines vastes séparées par une succession de chaînes montagneuses. La totalité de la côte calabraise, au sud de Sorrente, est également rocheuse et entrecoupée de vallées étroites s'ouvrant dans des bassins fluviaux plus larges. La côte de Lucanie est une large bande littorale plate, celle d'Apulie est généralement rocheuse, à l'exception de la partie située au nord de Bari qui s'étend jusqu'au promontoire de Gargano en s'applatissant. Du nord de Bari à Pescara, la côte est rocheuse, et au-delà, entre Pescara et Ancône, elle est généralement plate avec une succession de cours d'eau parallèles descendant des Apennins. Puis, d'Ancône à la frontière yougoslave, la côte reste plate en se réunissant à toute une série de vastes plaines qui aboutissent au delta du Pô.

Les îles de Sicile et de Sardaigne possèdent plusieurs vastes bassins fluviaux, mais la majeure partie de leur littoral est rocheuse.

L'ensemble du littoral méditerranéen jouit d'un climat méditerranéen tempéré, l'influence marine se faisant davantage sentir dans les îles, tandis que l'influence continentale (vents violents, chutes de neige) prédomine autour du golfe de Trieste. La moyenne annuelle des températures s'établit à 14-15^{o}C dans la partie nord de la côte et à 16-17^{o}C dans la partie sud. La pluviométrie varie entre 600 et 1.200 mm selon la latitude géographique et la proximité des montagnes.

Le couvert végétal du littoral italien a subi très fortement les effets des activités humaines et une grande partie de la côte a été cultivée dès les temps préhistoriques. La végétation naturelle est représentée par deux associations principales: celle de l'olivier et du caroubier avec des arbrisseaux tels que le myrte et le tamaris dans les zones plus chaudes et humides, et avec le chêne vert qui prédomine dans les secteurs plus humides du littoral et sur des sols plus profonds. Les habitats chauds, jusqu'à une altitude de 300 à 400 m, abritent le pin maritime (*Pinus pinaster*).

Les sols de la zone côtière italienne se composent avant tout de fluvisols (plaines), de cambisols (en terrain vallonné) et de luvisols qui en occupent la majeure partie. Les terres rouges (luvisols chromiques) peuvent être décelées sur les calcaires durs mésozoïques. Les vertisols, associés au régosols, envahissent les terrains argileux vallonés, surtout sur la bande côtière de l'Adriatique.

Un atlas des côtes italiennes a été récemment publié dans le cadre du projet de préservation du sol.

2. Dégradation des sols dans la zone côtière de l'Italie

Le problème crucial du littoral italien est celui de l'érosion hydrique, mais on a aussi signalé des cas d'érosion éolienne.

L'érosion en nappe caractérise les versants cultivés à pente douce, et l'érosion par ravinements s'observe sur les pentes abruptes d'argiles limoneuses d'origine marine pliocène et pleistocène, de même que sur les matières pyroclastiques des secteurs volcaniques.

Le ruissellement lessive les fines particules du sol tout en obstruant les lits des cours d'eau par des matières à grains plus gros. L'analyse comparative d'une série de photos aériennes prises sur une période de 12 ans a montré que l'accumulation de graviers grossiers s'effectue à raison d'une extension d'un demi-mètre par an.

Les recherches récentes sur l'érosion par les eaux ont été axées dans deux directions: (a) une meilleure compréhension des facteurs qui influent sur les processus érosifs; (b) l'identification des risques d'érosion.

En Italie, l'érosion très marquée des sols est due avant tout à une répartition défavorable des chutes de pluie et à la violence de celles-ci. Par exemple, en Calabre, il n'est pas rare d'observer des pluies ininterrompues d'une durée de 4 à 5 jours (à raison de 300 à 400 mm par jour). Il convient aussi de noter que les fréquents incendies de forêt favorisent l'érosion.

L'Italie peut se prévaloir d'une longue tradition en matière d'aménagement du territoire et de lutte contre l'érosion et les inondations. Dans l'Italie centrale, ingénieurs et agronomes ont édifié des barrages, des terrasses et d'autres ouvrages de protection dès le 18è siècle. Aujourd'hui, sous l'égide du Conseil national italien de la recherche, il a été créé un certain nombre d'instituts de recherche dans les domaines de l'hydrologie et de la protection du sol; ces organismes dont la liste figure dans le rapport national sont prêts à prendre part à la coopération internationale.

On a enregistré en maints emplacements un recul de la bordure littorale due à l'érosion marine. L'affaissement des plaines alluviales constitue un problème spécifique. Certaines de ces plaines s'enfoncent à raison d'l cm par an environ, et d'autres à raison de 4 à 5 cm. En plus des causes naturelles, ce phénomène est fortement favorisé par les activités humaines (ouvrages très lourds, élimination des déchets, pompage de l'eau et du gaz) et provoque une augmentation de l'hydromorphisme et une salinisation du sol qui détournent de l'exploitation de la terre.

3. Mise en valeur des terres agricoles abandonnées

Un grand nombre de terres ont été abandonnées sur les versants abrupts, notamment aux emplacements où les sols sont aisément soumis à l'érosion, peu profonds et stériles (comme les "Fascie" de Ligurie). L'auteur estime que ces terrains pourraient être reboisés. Dans la même zone, mais sur des versants moins raides, l'exploitation agricole s'est poursuivie et même développée grâce à l'irrigation.

Dans les régions du sud de l'Italie, de vastes étendues ont été reboisées après la guerre et elles fournissent aujourd'hui un bois d'oeuvre de bonne

qualité. Les pouvoirs publics encouragent ce processus en acquérant des milliers d'hectares en vue de leur reboisement et en ne soutenant l'agriculture que sur les meilleurs sols.

L'abandon des terres agricoles dans les plaines alluviales en état d'affaissement pose un problème grave, car leur remise en valeur nécessite des actions de grande envergure. L'une de ces actions consiste à pomper l'eau des cours d'eau pour l'injecter dans la nappe phréatique dans les zones où l'affaissement est dû à l'exploitation de la couche aquifère et du gaz.

4. Protection des terres agricoles contre l'expansion urbaine

On assiste à une urbanisation intensive de la bande littorale italienne, et ce pour plusieurs raisons majeures qui sont:

(a) la désaffectation que connaît l'agriculture (meilleures conditions d'emploi dans les secteurs industriel et tertiaire);

(b) implantation de nouvelles industries le long de la côte;

(c) départ en retraite d'habitants et d'exploitants qui ont abandonné leurs terres agricoles pour gagner la côte et s'y installer définitivement; essor de la construction immobilière, et notamment des résidences secondaires (pour les week-ends);

(d) aménagement de vastes complexes touristiques.

Près de deux cent mille hectares de terres arables ont été ainsi perdus au cours des 20 dernières années. Un exemple typique de ce phénomène est celui de la "Riviera romagnola" qui est devenue une enfilade ininterrompue de résidences longue de 50 km.

Le rapport national contient une carte très instructive de la zone urbaine de Cagliari, Sardaigne: on y voit les limites de l'agglomération en 1954, 1968 et 1977 et on peut constater que celles-ci ont rapidement empiété sur les terres agricoles des environs. L'auteur insiste sur la nécessité de dresser des cartes judicieuses de l'aptitude des sols et il est partisan du principe selon lequel les sols de catégorie I et II doivent être pleinement protégés. En recourant à de telles cartes pour l'aménagement urbain, on a déjà pu obtenir des résultats appréciables, notamment dans le Piémont. L'auteur souligne également l'importance qu'il y aurait à créer un service national de recherche et de protection des sols qui serait chargé d'établir une classification unique des sols et de prendre part, avec le concours d'architectes et d'urbanistes, à l'élaboration des plans d'urbanisme.

5. Besoins et possibilités en matière de coopération internationale

L'échange d'enseignements entre pays méditerranéens devrait s'effectuer au moyen de visites d'experts, de projets conjoints et/ou coordonnés, l'échange d'ouvrages et de publications pertinents. A cet effet, il conviendrait de créer un organisme spécial (centre ou service) qui serait chargé en permanence de la réalisation des activités.

L'Italie possède une vaste expérience et un certain nombre d'institutions dotées d'équipes interdisciplinaires en matière de protection des sols, si bien que des pays méditerranéens moins développés pourraient bénéficier de la coopération avec elle.

LIBYE

Auteur: Dr Khalil A. Suliman

1. Traits physiques et géographiques de la zone côtière de la Libye

La zone côtière libyenne s'étend entre la Tunisie et l'Egypte sur une longueur de 1.900 km. A l'ouest, en bordure de la frontière tunisienne, se trouve la plaine de Jefara, d'une largeur de 80 km, avec des dunes de sable clairsemées. Cette plaine est flanquée au sud d'un plateau d'une altitude de 600 à 1.000 m, aux contreforts abrupts. Plus à l'est, la plaine côtière rétrécit à une largeur de 3,5 km, puis celle-ci atteint à nouveau 22 km aux environs de Misurat. De Misurat à Benghazi, la zone côtière est une plaine jalonnée de rares dunes de sable, et elle se prolonge au nord-ouest jusqu'au plateau de Jebel Akhdar, large de 50 km et d'une hauteur de 1.000 m, situé en bordure de l'Egypte, et dont la topographie est de type karstique.

Le climat de la zone côtière se caractérise par une diminution abrupte des précipitations passant de 200-300 mm (et même 500 mm dans les environs de Derna) à 50 mm seulement, dès qu'on s'éloigne à quelques dizaines de kilomètres de la côte. La distribution des précipitations est méditerranéenne, autrement dit elles se concentrent dans la période automne-hiver. La température accuse de grandes fluctuations entre l'hiver et l'été (de 12 à 40°C). Des vents forts soufflent des déserts de la partie continentale.

La végétation naturelle est constituée d'un couvert d'herbes xérothermiques, de maquis et de pseudo-maquis comportant des espèces mèditerranéennes typiques (Juniperus pheonica, Pistacia lentiscus, Cistus parviflorus, Cupreses sempervirens, Ceratonia silica). Dans la partie centrale plus sèche de la zone côtière, on trouve les plantes sahariennes, et des halophytes sur les solontchaks.

La couverture du sol est représentée sur une carte pédologique au 1/50.000 assortie de cartes thématiques (cartes de salinisation, d'érosion et d'aptitude des sols). Le type de sol prédominant est le yermosol, tandis qu'on trouve environ 25% de ferralsol aux environs d'Akhdar et que la partie ouest se compose de cambisols chromiques. Dans les terres basses, on trouve également des zones restreintes de vertisol et de fluvisol, et les solontchaks représentent 15% de la superficie. Sur les roches calcaires prédominent les rendzines et les lithosols, et les arénosols aux emplacements des dunes de sable.

2. Dégradation des sols dans la zone côtière de la Libye

L'érosion du sol affecte la zone côtière puisque 70 à 80% de sa superficie sont exposés à l'action du vent et des eaux. Les facteurs contribuant au degré élevé d'érodabilité sont la texture légère, la végétation clairsemée, la faible teneur en matières organiques, le surpâturage et le matériel agricole inadéquat. L'érosion hydrique, particulièrement aiguë dans les hauts plateaux de l'arrière-pays, se manifeste sous forme de nappe ou de ravinements, alors que de vastes surfaces de la zone côtière sont modifiées par l'accumulation de dunes de sable.

Un projet de mesures complexes de protection contre l'érosion est mis au point par des experts de l'Union Soviétique. Des enseignements précieux ont

été acquis dans la lutte contre l'érosion éolienne. Diverses méthodes de consolidation des dunes sont appliquées; elles comprennent notamment l'emploi de matières végétales séchées, d'émulsions de pétrole, de bitumes artificiels, l'aménagement de ceintures forestières de protection. Ces expériences pourraient servir aux zones arides d'autres pays méditerranéens. Pour lutter contre l'érosion par les eaux, on aménage des terrassements, des ouvrages dans les lits des cours d'eau, des barrières, on pratique des labours selon les courbes de niveau, etc.

3. Mise en valeur des terres agricoles abandonnées

Dans la zone côtière de la Libye, la superficie des terres agricoles se monte à 3.000.000 ha, dont 2.400.000 sont arables. Comme la majeure partie de la production agricole dépend des chutes de pluie, les terres sont abandonnées pendant les années de sécheresse. Un abandon permanent intervient sur les terres devenues salines par intrusion de l'eau de mer dans le sous-sol, ou sur les terres atteintes par l'érosion. Les pâturages sont également abandonnés quand leur rendement devient trop faible par suite d'une surexploitation.

La remise en valeur des terres abandonnées repose sur une meilleure régulation du système hydrologique et sur la lutte contre l'érosion. On accorde une attention toute particulière à l'utilisation des eaux usées des réseaux d'égoûts pour l'irrigation, après leur avoir fait subir une épuration appropriée. L'auteur mentionne six grands projets qui ont apporté des solutions grâce à l'irrigation, à l'amendement des pâturages, à l'aménagement de bassins artificiels et au reboisement.

4. Protection des terres agricoles contre l'expansion urbaine

Une classification des sols selon leur aptitude a été réalisée pour les régions dont la pluviométrie dépasse 200 mm. Elle a défini sept catégories de sol, dont les trois dernières sont impropres à la culture et représentent une superficie totale de 1.800.000 ha. Toutefois, les données disponibles indiquent que la croissance urbaine s'opère surtout au détriment des meilleures catégories de terre. Les zones urbaines bâties occupaient en 1978 17,6% des terres de meilleure qualité, 6% des terres de bonne qualité et 1,6% des terres de qualité médiocre. Vu les besoins du pays en terre agricole, il a été adopté une législation qui attribue compétence au secrétariat de l'Agriculture pour toutes les questions d'utilisation de la terre agricole et les cas éventuels de morcellement. Le forage des puits relève de la responsabilité du même secrétariat. Pour chaque ville importante, il existe un plan d'aménagement jusqu'à l'an 2000 qui devrait écarter toute nouvelle menace de l'expansion urbaine sur la terre agricole.

5. Besoins et possibilités en matière de coopération internationale

L'expert libyen souligne notamment qu'il incombe aux pays méditerranéens de coopérer pour amender les sols salins, compenser les eaux pompées du sous-sol et évaluer les pertes de sol imputables à l'érosion éolienne. La Libye peut apporter son expérience dans la consolidation des dunes, l'amendement des sols montagneux et des pâturages. Le projet libyen le plus important consiste en l'aménagement d'une ceinture forestière à la partie sud de la zone côtière afin d'enrayer la désertification (projet international).

MALTE

Auteur: P. Muscat, ministère de l'Agriculture et des Pêches, La Valette

1. Traits physiques et géographiques de la zone côtière de Malte

Les îles composant l'Etat de Malte comprennent Malte (246 km^2), Gozo et Comino (316 km^2 à elles deux). Sur le plan topographique, l'ensemble du territoire appartient à la zone côtière. La partie occidentale de l'île de Malte est constituée d'un noyau dur de sol calcaire qui culmine à 250 m. Ce noyau est entouré d'argiles bleues. La partie centrale forme une plaine de calcaire tendre à base de globigérines. Des hauteurs occidentales descendent des vallées dont les cours d'eau se dirigent vers l'est et le sud-est. On retrouve la même structure sur les autres îles.

Le climat des îles de Malte est de type méditerranéen avec des étés secs et chauds (en juillet, on relève une température moyenne de 30°C) et des hivers doux et humides (température moyenne de 15°C en janvier-mars). La pluviométrie varie de 200 à 970 mm. L'humidité relative de l'air se situe entre 65 et 80%. Les vents dominants soufflent du nord-ouest et peuvent atteindre une vitesse de 9,1 noeuds/heure, provoquant une érosion éolienne.

La couverture végétale naturelle se compose de forêts à feuilles persistantes dégradées en garrigue (jasmin, caroubier, arbustes à feuilles persistantes); sur ces surfaces dégradées, on trouve fréquemment le pin d'Alep.

Certaines roches-mères de calcaire et argiles bleues sont recouvertes de rendzines et régosols récents extrêmement carbonatés, et on trouve sur des calcaires durs karstifiés des terres rouges et des lithosols. Les fluvisols se rencontrent dans les vallées des cours d'eau.

2. Dégradation des sols dans la zone côtière de Malte

L'érosion hydrique constitue la forme la plus grave de dégradation des sols à Malte. On ne dispose pas de mesures exactes suffisantes du degré d'érosion. L'effet érosif de la pluie, la végétation clairsemée, le relief accidenté et les substrats de forte érodabilité sont responsables de toutes les formes d'érosion due aux eaux. Le ruissellement torrentiel détruit souvent les terrasses de protection, très répandues dans cette région. Les matériaux entraînés par l'érosion sont déposés dans les plaines et la plus grande partie d'entre eux aboutit à la mer où ils occasionnent des dommages supplémentaires.

La dégradation du sol nécessite un emploi accru de produits chimiques qui aggravent la pollution et entraînent une dégradation biologique du sol et de l'environnement.

Des systèmes d'irrigation mal conçus aboutissent à la formation de zones marécageuses et à l'affaissement du sol.

La nécessité d'une approche intégrée des problèmes de l'érosion est soulignée; elle impliquerait la création d'un organisme central chargé de coordonner les activités des diverses institutions spécialisées. La principale mesure de protection consiste dans le terrassement des pentes qui est pratiqué à Malte depuis le XIXe siècle. L'auteur insiste également sur la nécessité d'une culture rationnelle de la terre et d'un reboisement en haut des

versants. Un grand projet gouvernemental de reboisement est en cours; il comporte notamment l'aménagement de ceintures forestières comme protection contre l'érosion éolienne. De précieuses expériences ont déjà été acquises dans ce domaine.

3. Mise en valeur des terres agricoles abandonnées

Le rapport ne fournit pas de renseignements sur les terres agricoles abandonnées, mais il en ressort que des efforts sont déployés en vue d'amender les sols et de les mettre en valeur, et d'activer les terres dénudées. Depuis 1976, 120.000 m^2 de terres sont intégrés chaque année dans le processus d'amendement. On s'attache notamment à l'enrichissement du sol en matières organiques afin d'accroître sa résistance à l'érosion.

4. Protection des terres agricoles contre l'expansion urbaine

L'essor accéléré de l'industrie et du tourisme ainsi que l'expansion urbaine ont, ces dernières années, fait peser une grave menace sur les terres agricoles. Dès 1973, une loi sur la protection des terres productives avait été adoptée. Elle visait à prévenir le transfert de terre d'un lieu à un autre, et la couverture d'une terre fertile par des matériaux stériles, à enrayer le développement incontrôlé. Cette loi est appliquée avec beaucoup de rigueur et le directeur du Service des terres et des eaux est pleinement habilité à trancher ces questions. Des inspecteurs du contrôle foncier veillent spécialement à la bonne exécution des décisions.

5. Besoins et possibilités en matière de coopération internationale

A Malte, une grande attention a été accordée à la formation des exploitants agricoles, et l'on escompte que cet effort conduira à une utilisation plus judicieuse de la terre. Toute coopération dans ce domaine serait manifestement très profitable.

MAROC

Auteurs: El Imbrahini Abdelkader, Diour Al Koumir, Trabiquet Salé

1. Traits physiques et géographiques de la zone côtière du Maroc

Le littoral de l'ensemble du Maroc est long de 3.000 km et le tiers en est constitué par la façade méditerranéenne. La zone côtière est séparée du continent par la chaîne du Rif (d'une altitude de 2.000 m) à travers laquelle de nombreux cours d'eau se frayent un passage jusqu'à la côte. Cette zone méditerranéenne comprend un certain nombre de plaines aux dimensions réduites.

La roche-mère présente une grande variété: calcaires, grès, marnes, ardoises cristallines, divers types de flysch. Dans la zone côtière alluviale, on trouve fréquemment des sédiments quaternaires. Les types de sol dépendent de la roche-mère et ceux qui prédominent sont les cambisols distriques, les luvisols, les rendzines, les régosols et, dans les terres basses, les fluvisols et les vertisols.

Le climat de la zone côtière méditerranéenne du Maroc est de type méditerranéen, les précipitations étant concentrées dans la période hivernale et revêtant fréquemment la forme d'averses. La valeur pluviométrique annuelle varie de 800 à 1.000 mm à l'ouest et tourne autour de 500 mm à l'est. La

température annuelle moyenne est de 17-18°C dans les zones basses et diminue en raison inverse de l'altitude. Les montagnes au-dessus de 1.600 m sont battues par des vents violents.

Le couvert végétal des zones basses se compose de groupements d'Oleo lenticetum, puis de diverses espèces de chêne méditerranéen avec divers arbustes typiques (lavande, éricacées). De vastes surfaces sont reboisées avec diverses espèces d'eucalyptus, acacia et peuplier ainsi que de pin (radiata, pinastar, pinea, canaris, brucia, halepensis).

2. Dégradation des sols dans la zone côtière méditerranéenne du Maroc

Au Maroc, l'érosion hydrique constitue le problème le plus aigu de la protection des sols. Elle a donc été la préoccupation majeure de plusieurs institutions compétentes depuis 1951, quand les premières lois et réglementations sur la protection des terres sont entrées en vigueur. Ces mesures reposent sur une longue tradition de reboisement et de culture des fruits et de la vigne sur les pentes aménagées en terrasses. A partir de 1971, la lutte menée contre l'érosion a revêtu une grande ampleur au Maroc. Des projets importants sont lancés avec l'aide d'organisations internationales. C'est le cas du projet MOR mené dans le bassin hydrographique du Nekor avec le concours de la FAO. Ce bassin, d'une superficie de 78.000 ha, passe pour être le plus érodable du pays. Les mesures de protection contre l'érosion doivent porter sur 20.000 ha, dont 40% sont constitués de pentes d'une déclivité supérieure à 50%, alors que seuls 18% ont une déclivité inférieure à 18%. L'intensité de l'érosion est de l'ordre de 8.000 t/ha par an. En même temps, cette zone a une forte densité de population, soit 75 habitants au km^2, avec un taux de croissance démographique de 2,7%. Environ 50% de la superficie totale sont constitués de terre arable et de forêts, dont environ 35% dans le cadre de cultures vivaces et 8,5% dans le cadre d'arboricultures. Il a été réalisé une classification des unités physiographiques au sein de la région. Chaque catégorie a fait l'objet d'un traitement distinct tenant compte du classement des terres, du climat, de la qualité du sol, de la géologie, de l'hydrologie et d'autres indicateurs.

Il a été mené un projet analogue intitulé DERRO dans le Rif oriental; il porte sur 250.000 km^2 et diffère du précédent en ce qu'il intègre aussi des aspects socio-économiques. Plusieurs études pilotes ont servi à l'élaboration de projets de développement intégré. Grâce à un traitement intensif (reboisement, bonification des pâturages, développement de la culture de fruits, amélioration des zones altérées par l'érosion, etc), 150.000 ha ont été mis en valeur jusqu'en 1985.

Les projets précités offrent une double portée pour la région méditerranéenne car il s'agit de projets intégrés à l'aide d'une méthodologie bien élaborée et dont on peut tirer de riches enseignements.

3. Mise en valeur des terres agricoles abandonnées

Au Maroc, ce sont pour la plupart des sols peu profonds situés sur les pentes qui sont abandonnés par suite d'une exploitation peu rentable et des dommages causés par l'érosion. Le reboisement s'est avéré être la seule méthode rationnelle de mise en valeur, notamment dans les zones moins peuplées, et il fait l'objet d'une vaste application au Maroc.

4. Protection des terres agricoles contre l'expansion urbaine

Les principales villes du Maroc sont situées dans la zone côtière et elles s'étendent au détriment des terres agricoles. Si la croissance démographique a atteint un taux de 5,6% pendant la période 1971-1982, celle de la population rurale n'a été que de 0,9%. Cette disparité illustre bien l'ampleur de l'expansion urbaine.

Jusqu'à présent, aucune législation n'a encore été adoptée dans le domaine de la protection des terres arables contre l'urbanisation. Les villes continuent à être les pôles du développement économique.

5. Besoins et possibilités en matière de coopération internationale

La méthodologie et les techniques mises au point au Maroc se prêtent à une application dans l'ensemble du littoral méditerranéen. En se fondant sur la structure physique, les éléments socio-économiques, les modalités d'utilisation de la terre, on a pu délimiter les zones suivantes aux fins de l'exécution des projets:

(a) villes englobant d'importantes agglomérations rurales, avec les zones industrielles;

(b) plaines et surfaces faiblement vallonnées (convenant à la culture des céréales et des fruits);

(c) zones montagneuses (forêts-paturâges);

(d) zones de haute montagne (secteurs forestiers nécessitant des mesures spécifiques de protection du sol);

(e) terres irriguées.

On a tiré des enseignements intéressants du reboisement des terres attaquées par l'érosion. Les résultats obtenus au Maroc à cet égard présentent une grande valeur et sont étayés par toute une série de données présentées dans le rapport pour chacune des cinq zones précitées.

TUNISIE

Auteur: Dr A. Souissi, Département des sols, ministère de l'Agriculture, Port de Tunis.

1. Traits physiques et géographiques de la zone côtière de la Tunisie

La côte septentrionale de la Tunisie est constituée par des plaines étroites séparées par un relief accidenté (300 à 400 m) et par des massifs plus élevés à l'ouest. C'est la région la plus humide du pays (pluviométrie dépassant 1.000 mm). La végétation naturelle se compose de chêne vert, de pin maritime et de pin d'Alep. De fréquents incendies de forêt (dévastant chaque année 0,5% du territoire) ont transformé de vastes étendues en garrigue et maquis.

La côte nord-est est formée de la vaste plaine de la Medjerda et de la plaine de Tunis qui sont isolées de la nordure littorale par des dunes de

sable consolidées ou mobiles. Le climat semi-aride de cette région se caractérise par des chutes de pluie de 380-400 mm inégalement réparties sur l'année et revêtant la forme d'averses. Les vents dominants soufflent du nord-ouest par violentes rafales. La végétation est à feuilles persistantes et associe des espèces méditerranéennes typiques (chêne vert, pin d'Alep, olivier, thuya et chêne liège). Les dunes mobiles ont été boisées avec succès par du pin maritime et de l'acacia.

Le cap Bon atteint 637 m dans sa partie centrale qui redescend en pente pour s'ouvrir dans des plaines en forme d'entonnoirs. La côte est généralement rocheuse, jalonnée de longues plages, de dunes et d'anciens lac salés dans sa partie orientale. Le bioclimat du cap Bon est semblable à celui de la région nord-est.

Le Sahel se compose d'une vaste plaine ouverte sur la mer dans sa partie orientale et d'un relief valloné (150 m ou plus) qui se transforme progressivement en un plateau à l'est et au sud (100 m). La bordure littorale fait alterner plages et portions rocheuses. C'est une région semi-aride d'averses sporadiques. La pluviométrie oscille autour de 400 mm par an dans le nord et 200 mm dans le sud. L'aridité est aggravée par le taux élevé d'évaporation (700-1.000 mm). Les bouquets de pin d'Alep poussant sur les flancs des collines cèdent la place à la steppe dans le sud et aux plantes halophytes dans les dépressions.

Le golfe de Gabès est un pays plat avec des lacs et des lagunes à sec, interrompus par des collines isolées. La bordure littorale est échancrée. S'y rattachent les îles de Djerba et de Kernna. Le climat est encore plus aride (précipitations inférieures à 200 mm) et l'évaporation dépasse les 2.000 mm. Une fréquence élevée de vents forts (16 m/s), des steppes éparses et dégradées caractérisent également cette région.

La partie nord et la plus humide de la côte, ainsi que les vallées de cours d'eau sont constituées de fluvisols à couche profonde. Les cambisols et les rendzines dominent sur les roches-mères calcaires, et le cambisol chromique dans la région semi-humide du nord-est, tandis que le yermosol calcique est le type le plus répandu dans la partie aride du Sahel. La sodification et la salinisation marquent les plaines alluviales. Des xérosols, à forte salinisation dans les dépressions, se rencontrent dans la vaste plaine située derrière Caussa. Dans la partie sud, la plus aride, on trouve fréquemment des croûtes de grès et de yermosol gypseux.

3. <u>Dégradation des sols dans la zone côtière de la Tunisie</u>

Le littoral tunisien est soumis à tous les types d'érosion. Se fondant sur les estimations du degré d'érosion par les eaux (méthode FAO, 1979), l'auteur remarque que la côte tunisienne est atteinte par une érosion en nappe modérée. D'une façon générale, la perte de sol due à l'érosion reste modérée et n'excède pas 7 t/ha/an, bien qu'elle atteigne des valeurs élevées avoisinant 60 t/ha dans certains secteurs (cap Bon).

L'érosion éolienne touche surtout le golfe de Gabès et la plaine côtière de la Djeffara (plus de 120 t/ha/an). On observe dans le nord des formes modérées de déflation, mais cette région est atteinte par l'accumulation active de dunes de sable marin. Dans les autres parties de la zone côtière, l'érosion éolienne est négligeable, les pertes qu'elle occasionne ne dépassant pas 10 t/ha.

L'érosion marine est par endroits très marquée. Outre les vents violents et le littoral sujet aux affaissements, l'érosion marine a été considérablement aggravée par les activités humaines (construction de barrages; nivellement de dunes pour l'aménagement de complexes touristiques; extraction du sable).

Depuis l'Indépendance, le gouvernement tunisien a pris d'importantes mesures pour la protection du sol. Jusqu'en 1984, près de 105.000 ha ont été reboisés aux fins de protection du sol et de l'eau; 15.000 ha l'ont été aux fins de consolidation de dunes et 10.000 ha pour constituer des ceintures forestières contre l'action des vents. Grâce à ces mesures, le ruissellement a diminué de 20 fois et les pertes dues à l'érosion de 10 fois. En association au reboisement, d'autres mesures ont été prises comme la construction de barrières anti-érosion et de petits réservoirs d'eau ("meskat").

3. Mise en valeur des terres agricoles abandonnées

Dans l'ensemble, on ne peut dire qu'il y ait en Tunisie de vastes étendues de terres agricoles abandonnées. Il s'agit plutôt d'exploitations individuelles délaissées pour ces motifs:

(a) inadaptation de la culture pratiquée au niveau socio-économique de l'exploitant;

(b) morcellement des exploitations agricoles;

(c) interruption de l'irrigation par manque d'eau, suivie d'une salinisation secondaire.

On a un exemple du premier motif dans la région du sud où les oliveraies âgées n'ont pas un rendement suffisant pour couvrir les coûts de production, notamment quand elles reposent sur des réservoirs d'eau mal entretenus. Le gouvernement tunisien a lancé un certain nombre de projets pour inverser cette tendance.

Le deuxième motif se rencontre surtout dans la côte nord et nord-est où 50% des exploitations ont une taille inférieure à 5 ha. C'est pourquoi un projet de loi est en cours d'élaboration afin de fixer un seuil de superficie et d'enrayer la poursuite du morcellement.

Une exploitation excessive des couches aquifères aux fins d'irrigation occasionne, dans les régions du nord et du nord-est, une chute du niveau piézométrique et une salinisation. La région de Tébourba, dans le Sahel, a été choisie pour y mener une expérience de recharge artificielle des couches aquifères grâce à l'aménagement de déversoirs.

4. Protection des terres agricoles contre l'expansion urbaine

Plus de 60% de la population vit sur l'étroite bande côtière tunisienne, et cette disparité côte/arrière-pays dans la répartition démographique ne cesse de s'accuser.

Les pressions croissantes qu'exerce l'essor immobilier, touristique et industriel ont conduit l'agriculture dans une situation critique qui nécessite de toute urgence la protection juridique des terres agricoles. On mentionnera

à titre d'exemple que les superficies affectées à l'expansion urbaine ont quintuplé de 1962 à 1974. Pareille évolution a imposé, en 1983, l'adoption d'une loi qui définit la terre agricole, les forêts et les pâturages et fixe trois catégories de zones: (a) les zones interdites; (b) les zones protégées; et (c) les zones assujetties à la délivrance d'une autorisation pour un usage particulier. Les zones des deux premières catégories bénéficient d'une forte protection et il est pratiquement impossible de les destiner à d'autres usages qu'agricoles. Les trois catégories sont indiquées sur une carte établie par le ministère de l'Agriculture.

5. Besoins et possibilités en matière de coopération internationale

La Tunisie pourrait bénéficier de l'expérience acquise par d'autres pays dans le domaine de la protection des sols en aménageant des terrasses et des haies (brise-vent) pour des cultures fruitières et maraîchères destinées à l'approvisionnement des marchés urbains et touristiques. Certains cépages et espèces de pommier des régions du nord et du nord-est résistent à la sécheresse et s'adaptent bien aux sols médiocres attaqués par l'érosion. Les enseignements acquis dans ces milieux devraient être compilés et évalués. Il conviendrait aussi d'étudier les possibilités de recharge des couches aquifères par les eaux usées et de leur protection contre la pollution.

L'auteur préconise la tenue régulière de séminaires pour étudier des questions choisies en commun, l'échange d'ouvrages et de publications par l'entremise du Centre régional du PAP, l'échange de visites entre les laboratoires et organismes s'occupant de la protection du sol en vue d'établir des projets conjoints et des formes de coopération.

TURQUIE

Auteurs: Dr Y. Kilinc, Université technique du Moyen-Orient, Département du génie civil, Ankara

1. Traits physiques et géographiques de la partie méditerranéenne de la zone côtière de la Turquie

La partie méditerranéenne de la zone côtière de la Turquie comprend les provinces de Nathay, Adana, Mersin et Antalya. A l'arrière-plan de la zone côtière s'étendent les chaînes montagneuses du Taurus (altitude de 300 à 4.000 m). Entre les versants montagneux et la bordure littorale, la zone côtière est occupée par des plaines dont les plus vastes sont celles d'Antalya et d'Adana. Les cours d'eau descendant des montagnes coulent dans de profonds ravins et forment de grands deltas à leurs estuaires. Une partie importante de la côte relève d'un relief karstique. Plus de 45% de la superficie est occupée par des versants à forte pente, ce qui entraîne divers types d'érosion.

Le climat de la zone côtière est de type méditerranéen. Sur les hauteurs, la moyenne annuelle des précipitations est de 1.000 mm, et elle est de 600 mm dans les parties basses. Les pluies ont un fort potentiel érosif, notamment en hiver et au printemps. La température moyenne annuelle est de 18°C.

Dans les zones de moindre altitude, la végétation se compose de maquis et de forêts bases de _Quercus cocciefra_, _Pistacia lentiscus_, _Laurus nobilis_, _Myrtus communis_. Dans les zones montagneuses, on trouve _Pinus bricia_, _Abies clicia_, _Pinus nigra_, _Cedrus libani_, _Quercus libani_, _Juniperus oxycedrus_.

Les types de sol de la zone côtière ne sont pas spécifiés dans le rapport.

2. Dégradation des sols de la partie méditerranéenne de la zone côtière de la Turquie

La Turquie dispose de données fiables pour la classification des sols selon leur utilisation dans les quatre provinces méditerranéennes. Elles ont permis une évaluation précise des types de dégradation du sol. Une étude géographique de ces données indique que la nature et le degré de la dégradation varient d'une province à l'autre. L'érosion hydrique est, de toute évidence, le type prédominant de dégradation des sols dans la zone côtière méditerranéenne de la Turquie. La salinisation, la sodification et la formation de marécages se produisent également à un certain degré, et l'érosion éolienne s'exerce dans quelques régions. Les incendies de forêt occasionnent de grandes dévastations qui ont touché, de 1950 à 1980, un total de 1.200.000 hectares.

Les principales causes d'érosion comprennent l'utilisation inappropriée de la terre, le surpâturage, le pourcentage élevé de versants abrupts et une vulnérabilité de la roche-mère à l'érosion. Au terme de dix ans d'efforts, la Turquie a dressé une carte de l'érosion sur la base de laquelle, ainsi que d'autres cartes d'utilisation des sols, sont appliquées des mesures systématiques de protection du sol. Cinq organismes nationaux sont chargés des aspects spécifiques de l'érosion, dans le cadre de tâches bien définies coordonnés par le Service de la protection de l'environnement. Au cours d'une campagne de protection des sols contre l'érosion (1972-1983), les interventions ont porté sur 86.000 ha, tandis que 10.700 ha de pâturages ont été amendés et qu'environ 1.000.000 ha de terres dégradées ont été reboisées.

3. Mise en valeur des terres agricoles abandonnées

Dans la zone côtière, les terres agricoles de bonne qualité ne sont pas abandonnées. Seules sont négligées les terres qui, d'anciennes zones forestières, ont été converties en zones arables. Cette conversion inopportune a entraîné la destruction de nombreuses zones forestières, et par conséquent aggravé l'érosion. Le reboisement de ces terres qui ont gardé un minimum de potentiel productif s'est avéré constituer la seule méthode valable de mise en valeur des terres abandonnées dans la zone côtière de la Turquie.

4. Protection des terres agricoles contre l'expansion urbaine

L'expansion urbaine et industrielle au détriment des bonnes terres agricoles est un problème qui se pose avec acuité dans la zone côtière méditerranéenne de la Turquie. L'auteur du rapport l'attribue à l'absence d'un classement approprié des utilisations du sol, car un classement d'ordre général ne saurait évidemment répondre à des fins spécifiques. Il reste aussi à résoudre des problèmes sociaux tels que les utilisations inadéquates et les détériorations du sol imputables à l'absence d'autres perspectives rémunératrices.

5. Besoins et possibilités en matière de coopération internationale

Bien des problèmes qui se posent conjointement dans plusieurs pays pourraient être résolus par la coordination des efforts et l'organisation de séminaires. L'un de ces problèmes a trait à la mise au point d'un modèle de

prévision de l'érosion. L'équation universelle de calcul de la perte du sol ne s'applique qu'à la terre cultivée et comporte des difficultés. Grâce à des eforts communs, il conviendrait de mettre au point de nouveaux modèles d'évaluation de la perte de sol par érosion, ce qui implique l'instauration d'un réseau de surveillance continue.

Depuis des années, la Turquie s'emploie à évaluer et déterminer les facteurs de l'équation universelle de perte du sol (EUPS). A cet égard, il est proposé de lancer un projet intitulé "L'érosion hydrique, conséquence d'une utilisation inadéquate des terres".

YOUGOSLAVIE

Auteurs: B. Milos, Institut de recherche de l'agriculture adriatique, Split

1. Traits physiques et géographiques de la zone côtière adriatique

La zone côtière de la Yougoslavie se compose d'un grand nombre d'îles et de la bande, comprise entre la bordure littorale et la ligne de partage des eaux, qui peut avoir plusieurs kilomètres de large. La longueur du littoral se monte à 2.000 km pour le continent et à 6.000 km quand on y ajoute le littoral des îles.

La côte adriatique est formée en majeure partie de roche-mère calcaire mésozoïque karstifiée. Dans certains plissements rocheux, on trouve du flysch tertiaire (alternance de calcaire, grès, marne, conglomérats) et au pied des massifs montagneux plus importants des accumulations de dépôts caillouteux quaternaires. Sur la majeure partie de la côte, des chaînes de montagnes élevées surplombent à la verticale la bande côtière très étroite. Les principaux cours d'eau ont ouvert des plaines alluviales en s'écoulant vers la mer. Le cours du Neretva a formé un vaste delta.

On peut distinguer trois régions bioclimatiques dans la zone côtière adriatique: la région sud a le climat le plus chaud, avec une moyenne annuelle des températures de 16°C environ; à l'extrême sud, les précipitations sont d'environ 300 mm, alors qu'elles atteignent 1.250 mm dans la région de Dubrovnik. Dans la région centrale, la moyenne annuelle des températures est de 15-16°, et la moyene pluviométrique est de 800 mm. Enfin, dans la région nord, les mêmes valeurs s'établissent respectivement à 13-14°C et à 800-1.400 mm. La répartition des précipitations est typiquement méditerranéenne, avec des averses fréquentes atteignant parfois 200 mm par jour. Des vents très violents caractérisent la région nord.

Le couvert végétal appartient à deux zones: (a) la zone euméditerranéenne des chênes à feuilles persistantes, avec la sous-zone de l'oliver/caroubier dans la zone littorale et les îles sud, et la sous-zone du chêne vert dans l'arrière-pays; (b) la zone de *Carpinetum orientalis* à feuilles caduques qui succède à la première zone et s'étend jusqu'à la zone subméditerranéenne. La végétation naturelle est très dégradée si bien que les deux tiers de la superficie sont recouverts de garrigue et de maquis. L'évolution de la végétation est gravement altérée par les incendies de forêt.

Sur la roche-mère calcaire karstifiée, on trouve fréquemment des sols de type lithosol, cambisol et luvisol chromique. Les rendzines apparaissent sur les marnes, les régosols sur les pentes abruptes et les cîmes montagneuses.

Les fluvisols peuvent se rencontrer dans les vallées fluviales et le delta du Neretva, alors que les sols salins et alcalins recouvrent les anciennes terres maritimes asséchées.

2. Dégradation des sols dans la zone côtière de la Yougoslavie

Le calcaire karstifié est une roche-mère moins vulnérable à l'érosion par les eaux. Toutefois, une érosion s'exerce en profondeur des formations darstiques, mais elle n'a pas encore fait l'objet d'une étude détaillée.

La répartition des précipitations sur le flysch est foncièrement différente de celle qui a lieu sur les surfaces calcaires. Sur les calcaires, 70% du volume total des précipitations s'infiltre dans le sous-sol, alors que sur le flysch 52% du même volume constitue le ruissellement de surface, 24% s'évaporent et 24% s'infiltrent dans le sous-sol.

Depuis 1976, les phénomènes d'érosion sont surveillés en permanence et enregistrés au site expérimental de Muc. La zone est formée d'un grès typique et pourrait être intégrée dans le réseau régional de stations de surveillance continue de l'érosion. Les données enregistrées sur le site, conjointement à d'autres mesures effectuées dans la zone côtière ont montré que la méthode d'utilisation de la terre et l'état du couvert végétal jouent un rôle déterminant dans la survenue de l'érosion. Cependant, les mesures de lutte anti-érosion appliquées jusqu'ici n'ont pas donné de résultats satisfaisants. Il semble nécessaire de créer de nouveaux centres expérimentaux pour la surveillance continue des processus d'érosion.

3. Mise en valeur de terres agricoles abandonnées

Il y a diverses raisons qui expliquent l'abandon des terres agricoles. Le faible rendement des sols pierreux et peu profonds, le morcellement des exploitations, la cherté de la main d'oeuvre et un profit médiocre ont principalement détourné de la vocation agricole dans la zone côtière. D'autre part, le développement du tourisme et de l'industrie ont provoqué un afflux d'habitants des îles dont la population a diminué de 8,3% de 1961 à 1971, et cette tendance risque de persister. La situation la plus grave sévit dans le vignoble et les oliveraies situées sur des sols peu profonds et des lithosols. La majeure partie de ces terres est impropre aux techniques modernes de culture et devrait donc être convertie en forêts - mais non spontanément car, dans ces zones, la croissance des arbres ne semble pas s'opérer d'une manière satisfaisante. Il incombe plutôt de procéder à la mise en valeur avec des espèces sélectionnées et l'application de mesures appropriées de sylviculture. A cet effet, il a été aménagé une station expérimentale où le comportement de diverses espèces d'arbres est étudié dans des conditions géologiques données. L'auteur suggère que ce site expérimental pourrait constituer une étude de cas intéressante pour d'autres pays méditerranéens.

Le vignoble aménagé en terrasses sur des lithosols, à Primosten, offre un exemple typique de sol impropre à l'agriculture.

La remise en valeur des terres abandonnées de haut rendement (sols sur flysch), avec l'application de mesures anti-érosion efficaces, devrait compenser la perte de terres agricoles moins rentables.

De plus, la mise en valeur des terres dans les vallées fluviales peut considérablement augmenter la capacité de production. L'un des projets de mise

en valeur couronnés de succès a été celui du delta du Neretva mis en oeuvre avec l'aide de la FAO.

4. Protection des terres agricoles contre l'expansion urbaine

Certaines parties du littoral adriatique sont parmi les régions de la Yougoslavie ayant la plus forte densité de population et qui ont enregistré, dans la période 1961-1971, un taux de croissance atteignant jusqu'à 7,6%. La période qui a suivi a été marquée par une nouvelle poussée de la croissance démographique en raison du boom touristique de la région. Comme la terre arable est très rare, l'expansion urbaine suscite de graves conflits entre les utilisateurs potentiels des terrains. Par exemple, la ville de Split a, au cours des dix dernières années, empiété sur 800 ha environ de terre de la meilleure qualité. Les mesures prises pour protéger la terre fertile contre les pertes de cette nature se sont malheureusement avérées inefficaces. Un facteur encourageant tient à l'adoption de lois visant à garantir un meilleur degré de protection des terres environnant les grandes villes. Cependant, un niveau élevé de décentralisation administrative ne facilite pas cet effort.

5. Besoins et possibilités en matière de coopération internationale

Les expériences et les connaissances acquises en ce qui concerne la protection des sols de la zone côtière yougoslave sont loin d'être suffisantes. Il incombe donc d'instaurer une coopération au niveau régional dans ce domaine afin d'accélérer l'accumulation du savoir requis. L'auteur insiste notamment sur la nécessité de créer un système informatique (banque de données) comme moyen de coopération plus fructueuse.

La Yougoslavie étant un territoire comportant de vastes zones karstiques, elle peut offrir sa propre expérience et certains sites pour la mise en place de stations expérimentales en vue de rechercher des solutions aux problèmes posés par l'hydrologie et l'écologie karstiques et auxquels sont plus ou moins confrontés tous les pays méditerranéens.

3. CONCLUSIONS

Par "zone côtière", on entend la bande de terre située en bordure du littoral et qui comprend les plaines côtières et les versants orientés vers la mer du relief montagneux de l'arrière-pays avec les cours d'eau à direction maritime. La ligne littorale de la zone ainsi définie coïncide avec la ligne de partage des eaux des bassins côtiers. Si la plaine côtière pénètre profondément vers l'intérieur, la zone côtière doit alors être définie par une autre limite naturelle de l'arrière-pays. En Afrique du Nord, par exemple, on constate une baisse pluviométrique brutale sitôt qu'on s'éloigne de la côte vers l'intérieur, si bien qu'à une distance de 50 km le climat méditerranéen fait déjà place à un milieu désertique. On retiendra donc la ligne où s'effectue ce changement climatique pour définir la limite intérieure de la bande côtière. Autre exemple: dans le delta du Pô, on retiendra la ligne jusqu'à laquelle on observe les caractères du bioclimat méditerranéen.

La géomorphologie de l'ensemble de la zone côtière de la Méditerranée est marquée par la diversité et l'alternance des éléments suivants:

(a) de vastes deltas fluviaux (Pô, Rhône, Nil, Neretva);

(b) des plaines étroites avec un arrière-pays montagneux;

. . .

(c) de vastes plaines et dépressions contenant souvent des lacs;

(d) des collines et chaînes de montagnes rejoignant la bordure littorale;

(e) des dunes côtières, typiques de la Méditerranée orientale.

Ces éléments géomorphiques se retrouvent dans l'ensemble de la zone côtière de la Méditerranée, mais ils se répartissent différemment selon chaque pays.

Le caractère climatique commun à tout le littoral méditerranéen consiste en la concentration des précipitations pendant les mois d'hiver, le plus souvent sous forme d'averses ou de pluies torrentielles qui augmentent le risque d'érosion dans l'ensemble de la région. En fonction de la quantité pluviométrique relevée, il est facile de distinguer dans la région une partie littorale occidentale humide et une partie orientale sèche et qui est, outre l'action des eaux, soumise à l'érosion éolienne et à la dégradation du sol par les processus de salinisation et sodification. Les régions semi-arides sont, pour la plupart, des zones de la mer très vulnérables à l'érosion.

Les roches-mères constitutives de la zone côtière de la Méditerranée sont très diverses. Les plus fréquentes sont les calcaires, les marnes, les roches et tufs volcaniques, les sédiments clastiques, divers dépôts alluviaux, des argiles bentinitiques, etc.

Les rapports nationaux qui l'on vient de résumer n'ont pas formulé de remarques sur l'applicabilité de la classification FAO des sols. Toutefois, comme tous les auteurs y ont recouru, on en déduira que son application est possible à un niveau mondial d'échange de l'information. Il sera sans doute nécessaire d'établir une corrélation plus poussée dans le cadre d'un projet détaillé.

Les rapports nationaux ont identifié les types suivants de sol: lithosol, rendzine, luvisol, luvisol chromique, fluvisol, gleysol, cambisol (eutrique ou districque), vertisol chromique, régosol, yermosol (calcique, gypseux), solontchak, solonetz, arénosol, xérosol, planosol, cambisol rhodo-chromique, cambisol calcaro-chromique, phéozem.

L'érosion par les eaux est un problème aigu qui se pose dans l'ensemble du littoral de la Méditerranée. Les principaux facteurs favorisant les processus d'érosion sont:

- le pouvoir érosif des pluies;
- la vulnérabilité élevée à l'érosion de certaines roches-mères (marne, tuf volcanique, dépôts éoliens, et certains sédiments pleistocènes mobiles);
- une utilisation inappropriée de la terre;
- un procédé de culture et d'assolement inadéquat;
- une mauvaise gestion des forêts;

- des incendies de forêt fréquents;

- une sodification des zones arides réduisant la capacité d'infiltration du sol.

Seules l'Egypte, la Turquie, la Libye et la Tunisie ont procédé à un inventaire des processus d'érosion et à une évaluation des risques d'érosion. Les mécanismes d'érosion dans des conditions méditerranéennes spécifiques tout comme la modélisation des processus d'érosion n'ont pas encore fait l'objet de recherches approfondies. C'est pourquoi l'expérience acquise par Israël dans ce domaine mérite la plus grande attention.

Les mesures traditionnelles de protection du sol contre l'érosion en Méditerranée (terrasses renforcées) ne conviennent plus guère car elles entravent la mécanisation des procédés de culture et l'accès aux véhicules. A l'exception de l'Italie qui a à son actif un bilan important en matière de protection intégrée des sols contre l'érosion, les autres pays méditerranéens en sont tout au plus à amorcer des projets qui devraient garantir une approche nouvelle du problème.

Dans les régions arides de la Méditerranée orientale, l'érosion éolienne pose un grave problème. A cet égard, la Libye dispose de données systématiques et peut faire état des mesures qu'elle a prises pour la protection du sol contre la déflation et l'accumulation du sable. Il conviendrait de proposer les sujets suivants comme études de cas éventuelles:

(i) recherche expérimentale des mécanismes d'érosion en rapport avec la sodification du sol (Israël);

(ii) établissement et utilisation de cartes d'érosion du sol (Turquie);

(iii) solution intégrée des problèmes relatifs à la protection des sols contre l'érosion (projets menés en France, Egypte, Tunisie, Maroc);

(iv) lutte contre l'érosion éolienne (Libye).

Dans les deltas des fleuves et les sections de la côte composées de sédiments tendres, l'érosion des plages est un problème sérieux (Egypte, Israël, Tunisie, Italie). L'Egypte et Israël ont acquis des connaissances et enseignements considérables dans la recherche et la lutte contre ce processus, et ces efforts pourraient constituer une étude de cas dans ce domaine particulier.

Les éboulements de terrain sont plus prononcés à Chypre mais touchent vraisemblablement d'autres pays. Les travaux menés à Chypre (projet de coopération internationale en cours d'exécution) pourraient également servir d'étude de cas.

La salinisation et la sodification des sols sont étroitement liées à un usage rationnel des ressources en eau. La principale forme de salinisation secondaire est due à la salinité accrue des eaux souterraines (couche aquifère) utilisées pour l'irrigation. La couche aquifère se salinise par suite d'un pompage excessif aux fins d'irrigation et de l'intrusion de l'eau de mer. On s'efforce d'y remédier en construisant des déversoirs et en rechargeant artificiellement la couche aquifère à l'aide de réservoirs

superficiels, ainsi qu'en recourant davantage à l'eau des citernes pour l'irrigation. La Tunisie a orienté ses recherches dans ce sens.

L'abandon des terres agricoles est un phénomène que la Méditerranée a fréquemment connu au long de son histoire et qui l'atteint autant, voire davantage, de nos jours. Les raisons en sont multiples:

- baisse de la fertilité des sols due à l'érosion, à la salinisation, à l'affaissement de la côte, etc.

- manque d'eau pour l'irrigation;

- morcellement des exploitations agricoles en-dessous d'un seuil de rentabilité;

- disparité entre les cultures pratiquées et les nécessités techniques et économiques de la production aujourd'hui;

- immersion progressive de la bordure littorale;

- cultures pratiquées sur des versants escarpés inaccessibles à la mécanisation;

- incendies ravageant les campagnes et les forêts;

- raisons socio-économiques incitant à l'exode rural pour occuper des emplois dans les secteurs du tourisme et de l'industrie.

La remise en valeur des terres abandonnées s'avère nécessaire car on enregistre dans maintes régions un manque de terre arable et que des sites délaissés ont perdu leur fonction économique et écologique. Lorsqu'on analyse les raisons qui ont conduit à cette situation dans la zone côtière méditerranéenne, on peut en conclure que cette mise en valeur nécessite un effort soutenu des pouvoirs publics ou des collectivités puisque pareil problème ne peut être résolu que par une approche systématique et des actions de grande envergure comportant notamment:

- l'implantation de vastes réseaux hydrotechniques;

- de vastes projets de reboisement destinés aux zones de faible productivité exposées à divers risques et qui ont cessé de se prêter à une exploitation agricole;

- des mesures politiques et fiscales qui inciteront les exploitants agricoles à poursuivre leur activité.

On trouve des exemples de ces tentatives en Italie (projets de reboisement sur vaste échelle), en Egypte (aménagement de réseaux importants d'irrigation), en Tunisie (réglementation du morcellement des exploitations et politique d'incitation à l'activité agricole), en Libye (six projets importants) et à Chypre (loi de remembrement des terres). Il convient de souligner que la remise en valeur d'une terre n'implique pas nécessairement qu'on en revienne à la culture originelle mais qu'on envisage les moyens les plus appropriés d'utilisation de la terre, sylviculture comprise. Il importe donc de considérer les questions de remise en valeur sous l'angle du classement des sols par aptitude.

Une répartition inégale des ressources naturelles a, dans certains pays méditerranéens, abouti à une concentration élevée de la population dans la zone côtière (Egypte, Tunisie, Chypre), alors que l'essor du tourisme, particulièrement marqué au cours des dernières décennies, a entraîné un exode rural vers le littoral dans tous les pays méditerranéens. Il en a résulté une expansion urbaine considérable et une perte irréversible de centaines de milliers d'hectares de terre fertile. A cette perte de sol productif s'associe une dégradation biologique et esthétique de l'environnement. L'acuité du problème dans certains pays (Israël, Tunisie, Egypte, Malte, Libye) y a imposé l'adoption de lois et réglements visant à maîtriser puis à inverser cette tendance déplorable. Il convient, à cet égard, de mettre l'accent sur les points suivants:

(i) il est indispensable que chaque pays ait un organisme central, composé de représentants de toutes les parties intéressées, qui soit chargé de toutes les décisions importantes et du contrôle de l'exécution des projets;

(ii) il incombe d'établir une classification nationale unique de l'évaluation des terres qui servira de base à l'identification des zones et catégories de terre relevant de divers régimes de protection;

(iii) les terres agricoles de la première et deuxième catégories doivent être pleinement protégées contre toute autre utilisation;

(iv) les pertes de terre arable devraient être compensées par l'acquisition de nouvelles terres grâce aux revenus locatifs urbains.

4. PROPOSITIONS

En se fondant sur l'analyse des rapports nationaux et en se conformant aux suggestions qui y sont formulées, il est possible d'avancer les propositions suivantes:

4.1. Le CAR/PAP devrait:

(a) organiser un échange permanent d'enseignements, d'ouvrages et publications;

(b) organiser des visites d'experts ainsi que la formation de spécialistes en matière de protection des sols;

(c) faciliter le transfert de connaissances entre pays méditerranéens;

(d) mettre sur pied des projets de coopération entre pays méditerranéens quand des problèmes communs nécessitent un effort concerté;

(e) favoriser la coopération entre les pays grâce à des missions d'experts.

4.2. Chaque pays méditerranéen devrait désigner une institution au titre de structure focale chargée de la coordination des activités de protection des sols dans sa zone côtière.

4.3. Il conviendrait d'instaurer une coopération et une coordination permanentes avec la FAO qui bénéficie d'une vaste expérience internationale dans ce domaine.

4.4 Des Journées d'étude rassemblant des experts méditerranéens devraient être organisées pour:

(a) présenter les études de cas proposées dans ce rapport de synthèse;

(b) envisager les perspectives de lancement d'un projet conjoint dans le domaine de la protection des sols contre l'érosion; pareil projet devrait intégrer et élaborer les éléments suivants:

- établissement d'un inventaire global des phénomènes d'érosion et d'une évaluation des risques d'érosion dans la zone côtière méditerranéenne sur une carte à l'échelle 1/1.000.000 (méthode FAO);

- implantation sur le littoral méditerranéen d'un réseau de stations chargées de l'étude et de la surveillance continue des processus d'érosion afin de fournir les bases à la mise au point de procédés agrotechniques optimaux de lutte anti-érosion et de protection du milieu côtier;

- choix d'emplacements (installations) où un projet moderne intégré de protection des sols contre l'érosion a été appliqué et qui pourraient servir de démonstration dans le cadre de stages de formation;

- mise au point d'un système unique d'information couvrant tous les aspects de la protection des sols contre l'érosion;

- pour pareil projet, il conviendrait de solliciter le concours et l'appui financier d'organisations internationales (FAO, CEE, PNUD).

4.5 Il conviendrait d'établir un document contenant: (a) une étude comparative des politiques foncières et des législations relatives à l'utilisation de la terre dans les secteurs urbains de la zone côtière de la Méditerranée; et (b) une récapitulation de diverses expériences acquises dans ce domaine. Un document de cette nature serait utile aux pays de la région pour définir leurs propres politique et législation foncières.

Les Journées d'étude (point 4.4 ci-dessus) devraient fixer des priorités et un plan de travail pour la suite à donner.

PROMOTION OF SOIL PROTECTION AS AN ESSENTIAL COMPONENT OF ENVIRONMENTAL PROTECTION IN MEDITERRANEAN COASTAL ZONES IN EGYPT

by

A. BALBA
Department of Soil and Water Sciences
College of Agriculture
Univesity of Alexandria
Alexandria, Egypt

1. HISTORICAL

The Mediterranean coast of Egypt extends about 1000 km from its western border at Salloum to the eastern border at Rafah.

Historically this coast has been populated since ancient times. Several towns flourished and became known as centres of different activities. In Sinai, the Horus Road was the main route to the east. In the west, Amonia (now Marsa Matrouh) was the starting port of pilgrims travelling to Amon Temple at Senturia (now Siwah Oasis).

The Mediterranean coast of Egypt remained almost deserted for a long period of time. It is only over the past 200 years that any attention has been paid to the existing towns. When the Suez Canal was dug (1859-1869), Port Said was constructed to cater for vessels entering or leaving the Canal. Later efforts were made to reclaim the salt-affected soils north of the Nile Delta. However, the western and eastern parts of this long coast were neglected. The Second World War caused considerable damage and left vast areas planted with explosive mines in the western region. In the eastern areas the Sinai coast efforts were much delayed due to foreign occupation and several wars which had taken place in Sinai since the First World War.

2. GENERAL DESCRIPTION

Geomorphologically, the Egyptian north coast can be divided into three regions; the western, starting from the western borders at Salloum to Alexandria extends about 550 km; the middle region stretches about 400 km from Alexandria eastwards to Port Said; and the eastern region consists of the north coast of Sinai from Port Said to Rafah extending about 200 km.

A common characteristic of the three regions is the sand dune area parallel to the shore line. Lakes. swamps or lowlands are generally present along the coast. The lakes are mostly linked to the sea and are considered important fisheries. Among these lakes are Maryut (not connected to the sea) southwest of Alexandria. A considerable portion of this lake was drained and added to the cultivated land. There is Edku Lake, 40 km east of Alexandria, El-Borullos Lake occupying a considerable area north of the Nile Delta between the two Nile branches, El-Manzalah Lake east of the Damiette Nile branch extending to south of Port Said and El-Bardaweel Lake in the north eastern corner of the Sinai Peninsula. No lakes exist in the coast west of Alexandria beyond Maryut Lake. Only low lands and swamps exist near the shoreline.

2.1 Climatic conditions

The Mediterranean coast of Egypt is characterised by the following:

(a) Rainfall

Annual rainfall varies considerably according to location and from month to month. The "wet" season lasts from September until March. The annual rainfall in the western region varies between 90 to 180 mm/year. In the middle region, Sakha Station, situated at a distance of 40 km from the coast, differs from other stations scattered in coastal locations. The annual rainfall is about 55 mm. However, Port Said Station situated on the coast and considered as the end of the middle region, has an annual rainfall of about 74 mm. The rainfall increases in the eastern region to 97 mm/year in El-Arish and to 223 mm/year in Rafah, the end point of the coast of Egypt. Rainfall decreases rapidly from the shoreline to the south in the interior, where there is no rainfall in summer. In spring and autumn storms occur giving rise to torrents.

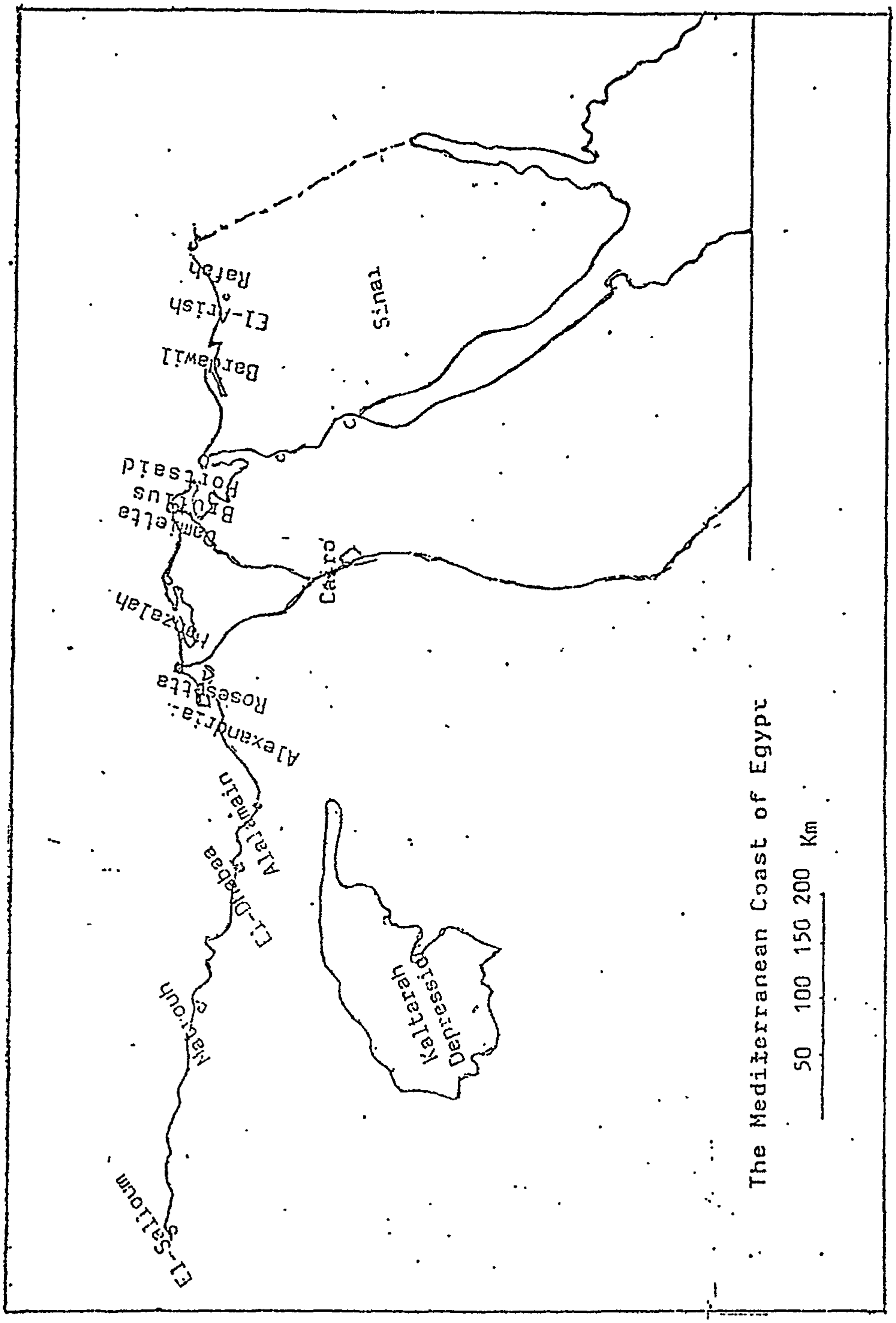
(b) Temperature

The temperature varies widely according to the season. In addition, there are considerable differences between day and night temperatures. The mean maximum temperature is about 23.9-26.9°C according to location. The mean minimum temperature varies between 14.2 and 18.5°C as seen in Table I. Maximum temperatures range between 30 and 32°C in August and minimum temperatures are between 6 and 9°C in January.

Table I

Meteorological records from observation stations along the Mediterranean coast of Egypt

Location	Pptn	Wind velocity km/hr	Temperature mean.max.	Temperature mean.min.	Evpn. mm	% Hum.
El Salloum	114	-	15.5	14.9	7.9	65.4
Sidi Barrany	156	-	23.9	15.0	6.25	70.0
Marsa Matrouh	154	10.0	24.0	14.6	7.7	68.3
Fukah	90	14.3	-	-	-	-
El-Daba	121	-	-	-	-	-
El-Hammam	106	-	-	-	-	-
Burg El-Arab	147	-	-	-	-	-
Amriah	144	-	-	-	-	-
El-Max	166	-	-	-	-	-
Alexandria	183	-	24.8	15.8	5.3	70.0
Port Said	73.5	-	24.4	18.5	-	70
El-Arish	97	-	25.2	14.2	-	70
Rafah	223	-	25.7	15.2	-	70
Sakha	54.8	-	26.9	14.8	3.9	72.2



The Mediterranean Coast of Egypt

(c) Wind speed

Less than 3% of the wind speeds are below 2 km/hr while 43% and 55% of the speeds at Matrouh and Sidi Barrany are over 20 km/hr. Such records are not available for other stations.

(d) Relative humidity

Table I shows recorded mean relative humidity percentages. The daily values are highest in the early morning and lowest at noon. During the Khamasseen Season, March-May, the relative humidity may drop to 10%.

(e) Evaporation rate

Recorded values in some stations show that this rate is high especially in summer. The mean values vary from 3.9 to 7.9 mm/day.

Despite the fact that the Mediterranean coast of Egypt is a semi-arid area as a result of the lack of rain and, despite its high temperature, its climate can nevertheless be considered as typically Mediterranean according to the data supplied by the observation stations.

The sky is fairly clear all the year round except for several cloudy days from November through March.

2.2 Geology geomorphology

2.2.1 The Western region (Alexandria-Salloum)

This region extends from Alexandria westwards to Al Salloum with a width of about 10-30 km from the seashore. A succession of ridges and depressions from the shore to the plateau characterises the topography of the area. According to Shata ( ) these ridges are composed of oolitic limestone. They are considered as the product of the consolidation of ancient littoral dunes formed along the shoreline. There are three ridges, each of which is separated from the other by a depression.

In the area extending from Alexandria to El-Hamman, the second ridge is about 0.5 to 1.0 km from the coastal ridge. The third ridge extends southwards forming the boundary of the dry bed of the left arm of Maryut Lake.

At El-Alamein, the Lake is so elevated that the two ridges are not distinct. A vast plain is formed extending to Fukah in the west. The El-Dhabaa area is characterised by an elevated coastal ridge and a wide plain with an elevation in its centre and a marsh covering its eastern part.

Further westwards several wadis and ravines are encountered especially west and south of Matrouh.

The area from Marsa Gargoub to Sidi-Barrany has few noticeable ridges. At Al-Salloum, there is a distinct coastal ridge running southeast towards Sidi-Barrany where it forms a low ridge in the south. Geologically the substrate in the coastal plains are mostly calcareous Pliocene and Pleistocene formations covered by various types of recent deposits mostly from loam and stones brought in by runoff, white calcareous sand of marine or littoral origin, reddish silicious sand deposited by wind and saliferrous or gypsiferrous clays deposited in the lagoons.

According to the SOGRIA Report (1975) on deep soil prospection boreholes several thousand metres deep showed Cretaceous and Tertiary series in which calcareous strata alternate with sandstone, clay and shale. A thick clay bed at a shallow depth acts as a foundation for the superficial calcareous formations and separates it from the underlying permeable horizon. The top levels of the clay in the boreholes were found to be 49 m in Burg El-Arab about 40 m in El-Dhaba, 23 m in Marsa Matrouh and 119 m in the Mamura (1) borehole in the Sidi-Barrany area.

2.2.2 The Middle region (Alexandria-Port Said)

The lakes constitute an important characteristic feature of this region. Edku west of the Rosetta Nile branch, Borullos between the two branches of the Nile and El-Manzalah east of the Damiette branch cover most of this coastal region. These lakes affect the soils as well as the inhabitants. Two major Egyptian ports, Alexandria and Port Said are located in this region, and the port of Damiette has recently been reconstructed. Fishing and all its requirements are the main occupation of the inhabitants. Agriculture was developed after the irrigation and drainage systems were established.

Sand dunes run parallel to the seashore line throughout the region. In between the dunes, low sandy areas with a shallow water table of about 40 cm from the soil surface prevail.

The soils south or between the lakes are generally flat with a shallow water table. There are scattered clay dunes especially in the area between the two branches of the Nile. A network of drains was established to discharge the drainage water. This area is integrated into the cultivated land of the Nile Delta. Generally, the soils are salt-affected unless reclaimed by leaching. Gypsum is frequently applied to improve the physical properties of the clay impermeable soils and to decrease their exchangeable sodium content.

In this region of the coast four geomorphological units can be distinguished: the coastal plains, flood plains, sand dunes and lacustrine flats. These units represent the marine, fluvial, aolean and lacustrine environments respectively. Overlapping areas between each two adjacent units also exist.

2.2.3 The Eastern region (The Sinai Mediterranean coast)

This region of the Mediterranean coast of Egypt extends about 200 km from Port Said, the Mediterranean entrance of the Suez Canal, to Rafah, the eastern border of Egypt.

Sinai topography is characterised by its plateau in the middle, sloping downwards to the Mediterranean Sea in the north.

The northern coast of Sinai can be divided into separate physiographic areas, the low land in the west, Wadi El-Arish and the Shiha Plain and the Rafah area.

- The low land

The western part of the Mediterranean coast of Sinai contains a series of large salty flats extending southwards from the coast. These flats are waterlogged during the rainy season. Behind the salty flats, there are gently undulating dunes. El-Bardaweel lake is situated in the

northwestern corner of this part of the coast. Eastwards along the coast towards El-Arish, the dunes are closer to the shore line, with only a few palm trees. There is no ground suitable for large scale cultivation. The elevation of these dunes might reach as high as 50 m above the level of adjacent land. Depressions are scattered in between the dunes.

Most of the dunes in this area have been stabilised by desert shrubs and by salts especially gypsum and calcium carbonate. However, there are some moving and partially moving dunes, especially around the date groves and to the south of the salty areas.

This part contains a number of drainage basins which annually receive considerable amounts of water from the Sinai Central Plateau in addition to the annual precipitation. Among the important drainage basins are the South Bardaweel Basin and the basins east of El-Manzalah and El-Morrah (Bitter) lakes. The north tidal flats seem to be an extension of Lake Manzalah.

- <u>El-Arish area</u>

The valley of Wadi El-Arish has a gently sloping floor from south to north within its flood area, and ranges from a width of about 1 km at the mouth of the Wadi to over 3 km in the central area. Large sand dunes encroach on the valley from both east and west. In the east they rise to about 40 m above the valley floor, while on the west the dunes rise to about 50 m. The bed of the stream swerves around these dunes westward. The floor of the valley shows a gently sloping surface from east to west until about 3/4 km from the stream bed, where there is a sudden drop of 2-3 m caused by flood erosion.

Just over 5 km from the coast, Wadi El-Ma'adar joins Wadi El-Arish on its eastern side. Surface indications suggest that it is very seldom that any large quantity of water actually flows down Wadi El-Maadar.

On the western side of Wadi El-Arish, the sand dunes rise more gradually from the coast. Approximately 2 km from the coast and due west of El-Arish town, there is a depression in the dunes over 2 km wide.

- <u>Wadi El-Arish/El-Shina Plain</u>

El-Shiha Plain lies at an average elevation of about 75 m above MSL. It is a large gently undulating expanse about 5 km in diameter and enclosed almost entirely by sand dunes. The surface of the Plain is sandy loam. Close to the Plain centre, there is a distinct series of depressions. The south eastern border of the Plain is bounded by Wadi Hareidin which in this area has eroded deeply into the land surface forming a sheer-sided gulley about 10 m deep. The mouth of this gulley, about half a kilometre east of the Abu Aweigila road, is less than 100 m wide. The floor of the valley west of the actual stream bed is broken by numerous erosion gulleys formed by runoff from the eastern dunes.

- <u>El-Arish Rafah</u>

The area can be divided into three main sections: (a) the desert sand dunes south of the main road, (b) the coastal sand dunes along the shore line and (c) the cultivable land in the east, south of the main road and between the desert dunes and the border.

The desert dune area extends eastwards from the valley of Wadi El-Arish, gradually widening to the south. On the northeast it is bounded by Wadi El-Kharubah which takes the form of a broad plain 1-2 km wide.

The coastal dunes extend from El-Arish to beyond Rafah. The dunes in the area from El-Arish to El-Kharubah are about 2 km wide and about 48 m above mean sea level. Beyond El-Kharubah the dunes gradually increase in width until they average 15 km, outstripping Rafah by over 4 km. Elevations in this area reach more than 55 m above MSL.

At Rafah the general elevation adjacent to the sand dunes is about 18 m above MSL. These low elevations adjacent to the southern edge of the dune strip give the impression of large drainage valleys whereas in fact they are the original land surface without the dune cover.

Further to the east the land surface varies from sharply undulating dune areas to gently undulating sand surface up to the borderline. Eastwards from the dunes, the cultivable soil and the natural vegetation increase. The land surface, however, is still very sandy.

2.3 Factors affecting soil formation

In both the Eastern and Western regions of the Mediterranean coast of Egypt, the most significant factors affecting soil formation are climate, parent material and topography.

The climate as described above leads to the formation of "Serozem" soils. The formation processes under arid conditions are slow and are mainly of a physical nature. Soil transportation by wind and water is the dominant factor.

The dominant parent material is limestone. Sandstone and metamorphic rocks may also be encountered. Wind-blown sand constitutes a major part of the soil in some areas. Water deposits usually fill the depressions and form the deep soils overlaying a thick layer of limestone. Gypsum occurs in the profiles at varying depths and is occasionnaly found in thick deposits from which it is mined.

The depressions between ridges are filled with water-borne materials which constitute the main potential agricultural soils. The lowlands are usually highly saline.

Topography also plays an important role. Areas surrounded by hillock "Karms" usually receive more water and deposits than other areas.

Because of the aridity of the area, the effect of vegetation on soil formation is not pronounced. The hot summers and low precipitation hasten the decomposition of the plant residues.

Soil profiles are not well developed. It was not always possible to trace an accumulation horizon. However, $CaCO_3$ showed a tendency to increase with depth. Also the texture tended to be finer.

According to the factors stated above, the following soils are common in the eastern and western regions of the coast:

(a) The profile is deep with bedrocks deeper than 1.25 m from the surface. No hard pans are encountered. The texture of the surface is fine sandy loam. The subsoil tends to be of finer texture. The colour is yellowish brown. The $CaCO_3$ content is about 30-50% with a tendency to increase with depth. The dominant parent material is limestone. These soils are formed from materials washed from the neighbouring hills and ridges, usually occupying the areas between ridges. They are level or gently sloping (Calciorthids, USA or Calxic Ermosols, WSM).

(b) Texture, colour, depth and $CaCO_3$ content are similar to group (1) soils. The main difference is the presence of a lime layer at a depth of 30-50 cm from the surface. The subsoil is compact and dry (Calciorthids, USA or Calxic Ermosols, WSP).

A saline phase of the soils of (a) and (b) may also occur. Saliorthids, USA or Ochric Solonchak, WSM).

(c) The soils contain gypsum at varying depths. It may be present as a hard pan of varying thickness and depth. Texture and colour above the gypsum layer are similar to those of soils (a) and (b). Salinity usually increases in the layer above the gypsum layer (Gypsiorthids, USA or Gypsic Ermosols, WSM).

(d) Texture colour and $CaCO_3$ content are similar to those of soil (a). The bedrock, mostly limestone is at a depth of about 40-70 cm from the surface. These soils are located in the elevated areas and also in the eroded lowland. Stones and gravels are generally found on the soil surface and in the profile layers (Lithic Torric orthent, USA or Lithisols, WSM).

(e) The texture is sandy, of a yellow colour and the profile is deep without hard pans. The main characteristic of these soil materials is its looseness (Psamments).

(f) The soils which occupy the hillsides show a marked increase in rock and stones of different size. In most cases the surface is hard and covered with pebbles (Lithic).

(g) These soils include the oolitic dunes bordering the sea coast. They are rich in $CaCO_3$ (Oolitic Calcipsamments, USA).

(h) The saline soils of dry lake beds and lowlands where the texture of the surface is sandy loam have subsoils which are loamy or clayey. Shells are usually encountered in the profile. Gypsum layers are frequent in many places. The water table is within 0.5-1 m from the surface.

2.3.1 Soils of the middle region (Alexandria-Port Said)

In the middle region from Alexandria to Port Said the soil is fine sand in the coastal littoral and rich in $CaCO_3$. The width of the strip is generally 40 cm in the areas between the sand dunes.

South and between the lakes, the land is low-lying mostly submerged by water from the saline lakes in winter. Areas drained and dried are at sea level. The soil of the region is generally made up of fluvio marine deposits, fine textured, clayey, poorly drained unless mixed with shells. The water table is shallow, about 50-100 cm from the surface. The soils are saline sodic (Salorthids) with high concentrations of salts on the surface before reclamation. Vast areas were leached, drained and irrigated with the Nile or drainage water and have been integrated into the productive land.

The FAO and the Special Fund sponsored the High Dam Soil Survey in Egypt (1960-1964). Some 14 M acres were surveyed. A land classification and potential for irrigated agriculture was carried out including maps. The area surveyed included a part of the northwestern coast (from Alexandria to El-Alamein) and the middle part of the Mediterranean coast. This survey describes the soils of the two coast regions as follows:

- <u>The western coastal zone</u>

  The soils are silt loam with clay loam subsoils. The silt loam topsoil may be very shallow or moderately thick. Other areas are covered by very deep silty clay loams, sometimes with thin coverings of wind-blown sand. Locally the silt clay loams are shallow and overlie hard rock.

  Further north, the marine lacustrine plain is bordered by a zone with rocky beach ridges running parallel to the coast, between which flat stretches (salinas) show soils similar to those of the marine-lacustrine plain. These are very shallow silt loam over clay loam subsoil, or locally the silt loam topsoil may be thicker. In places there are outcrops of the underlying limestone.

- <u>The coastal zone of the Delta</u>

  The clay soils of the Delta Plain are bordered towards the coast by a zone of low dunes and flooded sandy plains from 1 to 10 km wide or separated from this coastal sandy zone by lagoon lakes like Burullus and Manzalah.

  Deposited in the brackish waters of lagoon lakes and swamps inland of the sandy coastal barrier zone, the clay soils of the fluvio-marine marshlands contain little lime but much salt and gypsum. The exchangeable Na and Mg are high and the soils are therefore saline/sodic; they are all heavy clays, but locally loam subsoils may provide better drainage.

  Along the shores of lagoon lakes, there are swamps with clay soils which are younger phases of the fluvio-marine clays.

3. LAND SUITABILITY CLASSIFICATION

The FAO Special Fund Soil Survey classified the soils according to their potential suitability for irrigated agriculture and presented their potentiality on map sheets on a scale of 1:200.000 and 1:100.000 as follows:

- <u>Class I</u> (Very suitable)

  Soils which are very suitable for the development of irrigated agriculture, and which are expected to be capable of producing sustained and relatively high yields from a wide range of crops. There are no soil limitations. This class comprises the well-drained silt loam soils of marine lacustrine plains and older beach ridges in the Alexandria-Cairo and Alexandria El-Alamein areas.

- Class II (Suitable)

  Class II soils are expected to have a measurable lower productive capacity and are adapted to a somewhat narrower range of crops when irrigated. Some soil limitations may be present. Class II includes the following: Silty clay loam soils with a thin cover of wind-blown sand, shallow silt loam soils in the marine-lacustrine plains and on older beach ridges, some stretches of saline sandy clay loam soils of salinas in Alexandria-Cairo and Alexandria El-Alamein areas, very deep coarse sandy loam soils, locally with a thin covering of wind-blown sand in Alexandria-Cairo area.

- Class III (Medium suitable)

  Class III comprises soils expected to be of moderate potentiality for irrigation farming. The range of crops is appreciably smaller than in classes I and II. There are rather serious soil limitations, such as shallowness of the soil over rock, local coverings of wind-blown sand, coarse texture or very fine texture, stratification of the profile, gullying and water tables at depths of less than 150 cm. Class III includes very shallow silt loam soils with local thin coverings of sand over marine lacustrine plains and on older leach ridges in the Alexandria-El-Alamein area.

- Class IV (Suitable only under special conditions)

  This class comprises soils of limited use for irrigation agriculture. There are usually more severe soil deficiencies, mainly because of the texture and discontinuities in the profile which will create problems of water and plant nutrient availability or problems of drainage. Yields of traditional crops will cover the cost of production.

- Class V (Suitability to be determined after further detailed investigations and with reference to special soil amelioration practices).

- Class M (Miscellaneous land types)

  Only very limited areas within this class may have some agricultural potentialities.

4. WATER RESOURCES

4.1 Rainfall

It has been stated above that precipitation varies from one place to another along the coast and abruptly decreases as we proceed from the coast inland.

An annual average of 190 mm falls along the coastal strip extending from Alexandria to Borollus, while only about 73 mm per year falls in the strip stretching from east Damietta to Port Said. In the Rafah area the annual rainfall is about 230 mm.

The rain may fall as thunderstorms and accordingly water runs off carrying the soil material to the sea. Wadi El-Arish is an example of such a

major runoff in the coast. In rainy years, rainwater which falls on the elevated Sinai Plateau accumulates and forms a torrent current which cuts into the land transporting its deposits to the Wadi in the north, near the town of El-Arish. A dam was established to protect the town and its vicinity, but wars and foreign occupation destroyed it. The Al-Rawafaa Dam was 12 m above the wadi level and 70 m wide, with a storage capacity of 3 Mm^3.

The rain falling on any given area in the region is insufficient for agriculture. The problem to be solved is how to increase the amount of water penetrating into the ground and how to maintain it there long enough to enable the plant root to draw adequate supplies. A small part of the rain either runs off into the sea or infiltrates deep down. Much larger quantities are lost by evaporation from the surface.

The water has to be diverted to deep soils where it cannot evaporate too quickly if it is to be used to its best advantage. The soils selected for this purpose will furthermore have to have a fair degree of water-retaining capacity in order to keep the losses (from infiltration into the underlying calcareous formations) as low as possible.

Except for certain cases (dune areas) it would be inadvisable to let the water infiltrate down to the water table, as it would then be very difficult to recover. It would also tend either to become saline immediately or later on under the effects of pumping.

Water conservation practices are of special importance in both the western and eastern parts of the Mediterranean coast of Egypt. However, at present little attention is given to these practices as in the case of El-Rawafaa Dam and the dykes established in Marsa Marrouh area.

These were traditional practices of water conservation. Rain was stored in "cisterns" which are "water storages" cut out of the rocks or built in loose soils. These are provided with streamlets which lead the rainwater to the cistern's entrance. Thousands of these cisterns were built in ancient times but most of them are not in use at present.

Another system of rain conservation made use of in the past was to surround an area with "karms". The "karms" consist of elevated hillocks which collect water in the inside areas. The capacity of a "karm" varies from 15000-25000 m^3.

4.2 Surface groundwater

Considerable numbers of wells have been dug in the eastern and western regions of the Mediterranean coast of Egypt. Several new wells were dug or cleared and windmills were supplied to help lift the water. Several studies to evaluate the depth and quality of water of these wells were carried out.

Shallow wells of 2-10 m are common in the coastal sand dunes where the rain percolates and collects in the dunes. The quality of water in these wells is excellent as the total soluble salt content may be as low as 250 ppm.

Water may be collected in deeper strata in the wadis. The depth of the water-bearing layer varies from 10 to 35 m. The discharge from these wells varies. One well near El-Arish discharges 40-80 m^3/hr. However, the water quality is quite variable. The total of dissolved solids in the well water beside El-Arish was about 2564 ppm. In other wells, the water contains as

much as 10,000 ppm of soluble salts. The US.Sal.Lab. scheme for assessing water quality for irrigation (1954) was used by several investigators (................). This system takes into consideration the soluble salt content (EC), the ratio of Na to Ca+Mg (SAR), the residual (HCO_3+CO_3) and the baron concentration.

According to the US.Sal.Lab. Scheme, most of the well waters analysed were of poor quality. However, their low residual (HCO_3+CO_3) and the high $CaCO_3$ content in the soil may make it possible to use the water of a number of these wells for supplementary irrigation, provided tolerant plants are selected (usually olives, figs or almond) and other measures are applied to decrease the water salinity hazards.

5. SOIL DEGRADATION

5.1 Methods of assessment

The FAO (1979) defines soil degradation as the processes which lower the current and/or potential capability of soil to produce quantitatively and/or qualitatively goods or services.

The processes which cause soil degradation can be grouped into the following categories:

1. Water erosion includes splash-sheet gully erosion and various types of mass movement such as landslides, mudflows and solifluxion.

2. Wind erosion includes both the removal and deposition of soil particles by wind action and the abrasive effects of moving particles as they are transported.

3. Salinisation and sodification.

4. Chemical degradation as leaching of bases and build-up of toxicities other than those due to excess of salt.

5. Physical degradation refers to adverse changes in the physical properties of soil including porosity, permeability, bulk density and structural stability.

6. Biological degradation refers to processes that increase humus mineralisation rates.

The last three categories are not as active in the coast as the first three.

List of soil degradation classes active in the Mediterranean coast of Egypt, 1:5 m scale (FAO-Prov. Methodology 1979)

Water erosion (E):

	Soil loss t/ha/year	or mm/year
none to slight	<10	<0.6
moderate	10-50	0.6- 3.3
high	50-200	3.3-13.3
very high	>200	>13.3

Wind erosion (CW):

Class limits for soil loss as for water erosion.

	Salinisation (Sz):	Sodification (Sa):
	Increase in EC 0-60 cm layer	Increase in ESP 0-60 cm layer
none to slight	$<$ 2 mmhos/cm/year	$<$1 ESP/year
moderate	2-3 mmhos/cm/year	1-2 ESP/year
high	3-5 mmhos/cm/year	2-3 ESP/year
very high	$>$5 mmhos/cm/year	$>$3 ESP/year

The provisional methodology for soil degradation assessment (FAO, 1979) adds an assessment of the soil state to indicate the soil tolerance to degradation:

1. Water erosion:

Condition	State	Tolerance
Soils 10 cm deep	State I	no tolerance
Soils 10-50 cm deep	State II	little tolerance
Soils 50 cm deep	State III	normal tolerance

2. Wind erosion:

Condition	State	Tolerance
Soils with texture class 1	State I	no tolerance
Soils with texture class 2	State II	little tolerance
Soils with texture class 3	State III	normal tolerance

The texture classes refer to the textural classes of the FAO/UNESCO Soil Map of the World: 1 = coarse, 2 = medium, 3 = fine.

3. Salinisation:

Condition	State	Tolerance
Soils which have $EC_e >$ 15 mmhos/cm at 25°C at some time of the year, within 125 cm surface when the weighted average texture class of the surface is coarse, within 90 cm for medium textures, within 75 cm for fine textures or 4 mmhos/cm within 25 cm of the surface if pH (H_2O1:1) exceeds 8.5.	I	no tolerance
The soils which, in some horizons within 100 cm of the surface show electric cond. values of the saturation extract higher than 4 mmhos/cm at 25°C.	II	dependent upon crop type
Soils which within 100 cm of the surface have EC_e lower than 4 mmhos/cm at 25°C.	III	dependent upon crop type

4. Sodification:

Condition	State	Tolerance
Soils having saturation with exchangeable Na of more than 15% within the upper 40 cm of the horizon, or more exch. Mg plus Na than Ca plus exchange acidity (at pH 8.2) within the upper 40 cm of the horizon if the saturation with exch. Na is more than 15% in some horizons within 200 cm of the surface.	I	no tolerance
Soils which have 6% ESP in some horizons within 100 cm of the surface.	II	dependent on crop type
Soils which have less than 6% ESP within 100 cm of the surface.		

5.2 Soil erosion in the coastal area

Erosion, sand dune creep and wind-blown sand are usually pointed out as problems of agricultural development in the coastal region of Egypt. Yet studies of these problems received little attention for different reasons. Establishing wind breaks was practised in all agricultural projects in the region. Stabilising sand dunes was carried out on an experimental scale. In addition, water conservation practices in the region are very limited.

Sheet erosion can result in the almost complete break-up of certain soils over large areas, especially where the natural vegetation is in the process of dying out. Gully erosion is typical of the intense runoff zones in the catchment areas and the beds of the principal streams. However spectacular it may be, its action is actually much more limited than that of sheet erosion and much smaller surfaces are thus affected.

Accumulation processes also occur in all the current water-spreading zones. Their intensity varies very widely depending on runoff values and the size of the zones. Water and wind erosion also takes place and helps accentuate the degradation of certain soils. The erosion and accumulation process are all the more important as they alone often determine the possibilities of developing agriculture in a given area.

El-Feel and Fahmy (1972) found out that the rate of runoff in a location in the Maryut Extension Project some 40 km west of Alexandria was 0.19 ft^3/Sec/acre. They stated that this rate represents the basic figure for calculating the effective design for protection of land in the area. Their study included the length of the stream channel from aerial photographs under the sterioscope and the analysis of rainfall data of 15 years in order to find the relationship between intensity, duration and frequency.

5.2.1 Water erosion

From the description of the soil in the Mediterranean coast of Egypt, stated above, the following characteristics enhance water erosion in the western and eastern regions of the coast:

(a) Climatic factors

The climate of both regions is considered arid with the eastern region receiving less rainfall. However, in both regions, the rainfall frequently occurs as short heavy storms forming torrents which favour moving soil material.

(b) Soil

The loess-like soils of Wady El-Arish in Sinai and in several areas in the western region encourage gully formation. Gully erosion conditions are typical in the zones of intense runoff in the catchment areas. Sheet erosion takes place in soils over large areas especially where the natural vegetation is limited.

5.2.2 Wind erosion

(a) Climate

Wind erosivity increases with wind speed and decreases with the precipitation effectiveness of Thornthwaite. About 50% of wind speeds are over 20 km/hr, which accentuates the wind erosivity.

(b) Soil

Vast areas in the coast consist of sand, and thus the soil particles lack cohesive materials, which renders them prone to erosion. This is particularly noticeable in areas where the vegetative cover is scarce.

5.2.3 Seawater erosion

Early in the 20th Century, erosion of the shoreline of the Mediterranean coast of Egypt was observed especially after the construction of the old Aswan Dam in 1901. However, this erosion was counteracted naturally by the Nile's annual deposits which used to amount to about 70-80 M t. Studies indicated that one-third of this amount of alluvium used to be lost in deep seawater and about 22 M t of alluvium was deposited at the sides of the two branches of the Nile, Rosette and Damiette branches.

After the construction of the High Aswan Dam, these deposits ceased as they are now retained in Nasser Lake in front of the Dam. Erosion of the shoreline especially in the vicinity of the Nile discharge ends abruptly increased. From 1964 to 1970, the erosion of the shoreline was at an average annual rate of about 70-92 m and doubled to an average of 180 m from 1970 to 1982.

The Institute for Coast Protection, National Academy of Scientific Research and Technology, had initiated a system of monitoring and research. A Governmental organisation for carrying out protection projects was established, in charge of constructing walls to protect the coast. A part of these projects was executed in the strengthening and heightening of the Mohammed Ali wall in Abukeer Gulf east of Alexandria, the eastern port of Alexandria, increasing the depth of the Idku Lake entrance, protecting the town of Borullus and its protecting wall, protecting Ras El-Bar at Damiette and El-Gameel at Port Said.

There was severe erosion at Rosette and considerable damage has occurred. A plan was made to combat this problem by constructing a wall inland, carried out in 2 phases. The first phase is a wall at the eastern side of the Nile branch 12 m high and 9 m deep. The second phase is a wall at both sides east and west of the Nile branch 1620 m long and another 3600 m long at the eastern and western "tongues" of the Rosette branch. The investments needed for the first and second phases about 100 and 150 M Eg A., respectively. National and international firms are ready to give their bids for the first phase.

5.3 Salinisation and sodification

The coastal areas adjacent to the sea or the lakes may experience an increase in salts during storms and high tides. Low-lying areas adjacent to lakes, lagoons or swamps and having shallow saline water tables acquire more salts on their surface during dry hot seasons. Also salinisation may take place due to inefficient irrigation and/or drainage systems in areas where development projects were executed.

The climatic conditions favour the salinisation process.

Sodification may be present in the vicinity of lagoons and swamps.

Work on assessing soil degradation in the Mediterranean coast of Egypt is scarce. The FAO map 1:5 M had evaluated the factors of soil degradation in Africa north of the equator and the Middle East region. Using this map to obtain an idea as to the degradation processes in the Mediterranean coast of Egypt, the following values were obtained from maps compiled from general information by means of local observation (consultant reports).

Rainfall erosivity index	:	50 (moderate)
Wind erosivity index	:	150 in the west (high)
	:	50-100 in the middle of the Delta (high)
	:	50-100 No. in Sinai coast (high)
Climatic indices for salinisation and sodification A (arid)	:	1.5 $(\frac{PET}{PX10})$ (very high)
Climatic index for chemical degradation	:	= 0
Biological degradation	:	= 0.5 (slight)

Evidently, the indices presented above might differ from one location to another with differences in the soil texture, depth of groundwater table and degree and kind of natural vegetation cover. Also, these indices will change with the introduction of irrigation in the region as has already occurred in the western area of the coast.

Thabet, H. The Sea attacks our northern shores. Al-Ahram, 22 May 1983.

6. RECULTIVATION OF ABANDONED AGRICULTURAL LANDS

The activities of the population of the Mediterranean coast of Egypt were variable including farming, grazing and fishing.

Several natural as well as political factors led to the deserted state prevalent for a long period in this coast.

Studies by Shafey (1952) indicated that the Mediterranean coast of Egypt subsided about 2 m at some point in the 10th Century A.D. This disaster was a major reason for abandoning the whole coast. It seems that the western region of the coast was devastated by Bani Helal tribes on their way to Tunisia in the 11th Century. The restlessness and miseries which prevailed during the Turkish occupation affected the whole country. The population of Egypt at the end of that era had dwindled to 5 M. During the British occupation, both the western and eastern (Sinai) deserts were closed military regions. The Egyptians had to obtain permits to enter any of the two regions. Sinai has been in a state of war since the first world war. Only in 1983 was almost all the Peninsula (except Taba) freed from foreign occupation.

The agricultural developments in Egypt in 1850-1952 did not cover the western and eastern regions of the Mediterranean coast of Egypt. In addition to those stated above, several factors had led to limited efforts to develop the northwestern or eastern regions of the coast:

(a) Egypt has been paying full attention to the development of the utilisation of the Nile water. It is more feasible to deliver Nile water to the low clay fertile, highly productive lands in the Nile Valley and Delta rather than by transporting it to the adjacent desert land;

(b) both the eastern and western regions of the coast are sparsely populated. Any development activity should depend on migration and rehabilitation;

(c) uncontrolled grazing, specific soil properties and climatic conditions accentuate wind erosion as described above. Accordingly, wind erosion and sand movement are common in the western as well as the eastern regions of the coast;

(d) though rainfall hardly surpasses an average of 150 mm/year, yet it is characterised by its relatively high intensity causing loss of soil and water by runoff to the sea. Soil and water conservation measures which were practised in the past are now neglected.

The Egyptian population had reached 47 M by 1984, living almost totally in the Nile Valley and Delta. The population density in this area reaches as high as 200/km^2. Egyptian efforts were directed to the desert areas adjacent to the Delta. The western coast began to have attention early in the 1960's, but Sinai had to wait till it was freed from the foreign occupation in 1983.

6.1 Areas suggested for recultivation activities

In the littoral extending about 1000 km there are several factors involved in preferring one location to another.

In the northwestern region, it is planned to depend on the Nile water in the western part from Alexandria to El-Dhabha, a strip 150 km long. An area of about 7000 ha (60 km long) has already been irrigated by the Nile water.

Work is under way to complete the plan.

In the western part of the northwest coast, especially in the Matrouh area, water conservation, harvesting and storage and surface groundwater utilisation are the bases of land development.

Prior to digging canals in the eastern part or constructing dykes and water storages in the western part of the northwestern region, a soil survey was carried out followed by a land use classification (Balba and El-Gabaly, 1967). They classified the land according to its suitability for cropping as follows:

(i) The areas of sandy loam soils having deep profiles are most suitable for fruit trees.

The roots of trees extend deep in the soil profile searching for soil moisture, and young trees require special care and supplementary irrigation especially in summer until they establish their root system. In the eastern part where the Nile water is available, this requirement is satisfied. In the western part, however, water conservation and storage in cisterns are suitable techniques when extra water is needed.

Factors involved in successful tree-growing:

- The depth of the soil profile;
- Spots surrounded by hillocks are preferred because of the better chance to receive more rainwater by runoff;
- The high salinity of soil or well waters used for supplementary irrigation adversely affects the growth of trees;
- Salt-tolerant, drought-resistant trees are more suitable for the western part where Nile water is not available.

(ii) Soils of a second class of suitability which includes the saline phase of groups I and II and the soils of the Maryut Lake dry bed were suggested for crop production after leaching if necessary and under irrigation. Barley is the main crop in rainfed agriculture in the western part, whereas variable kinds of crops and vegetables can be grown under Nile water irrigation.

(iii) The eroded soils of groups I and II constituted class 3 (in the suitability for agricultural use classification mentioned above). Gullies, ravines and rocks of different sizes cover the surface of the soil. These soils require effort for runoff control after which it can be put into pasture.

(iv) The soils with gypsum layers. The utilisation of these soils depends on the depth and thickness of the gypsum deposits.

(v) The soils with shallow profiles to the bed rock. The soils of the fourth and fifth classes can best be utilised by barley or pasture.

(vi) Rocky soils of no agricultural value.

(vii) Loose sand.

(viii) Coastal dunes where fig trees proved successful. Land utilisation maps for 50,000 ha in the northwestern coast region were made showing the area as suitable for each kind of utlisation (Balba and El-Gabaly, 1967).

In the eastern region, the Sinai coast, the Rafah area receives more than 200 mm of rainfall. The soil is loess-like loam. Dry farming has a better chance than in any other part of the coast.

The northern part of Wadi El-Arish contains the most suitable soil. Controlling the water in the Wadi was attempted by constructing El-Rawafaa Dam (3 M m^3). However water conservation of the whole Wadi requires reconstruction of the dam and the further construction of one or more dams in selected sites.

A project to introduce the Nile water to the western part of the Sinai coast is under way. The irrigation canal will pass under the Suez Canal in pipes. About ..??...ha will be irrigated.

6.2 Land use

The most common types of land use in the Mediterranean coast of Egypt are:

(a) Irrigated farming
(b) Dry farming
(c) Grazing

Irrigated farming is the main land utilisation in the middle region north of the Nile Delta, and in the area of the western region where Nile water has been introduced since 1965. The area north of the Delta was reclaimed salt-affected soil. Irrigation and drainage systems were established. The soil was leached and has become productive land. Rice, cotton and sugar beet are the main crops in production. Milk production was taking place even before the land reclamation.

In the northwestern region, conditions are different from the north of the Delta. The environmental impact of the changes which had taken place were not given serious consideration.

The problems of the western coast after introducing the Nile water can be summarised as follows:

- Irrigation water was introduced through a network of canals but drainage was postponed;

- The flood irrigation method applied to the soils of the Nile Valley was used to irrigate the relatively coarse-textured soil which resulted in the rise of the ground water table and the soil salinisation.

The change due to intensive irrigated cultivation accelerated the rhythm of transformation from subsistence to market economy, so that the region became an integrated part of the market economy of the whole country. This change was accompanied by a growth in tourism in the region which further accentuated the factors of socio-economic changes.

- Seepage from the main irrigation canal caused the formation of a pool in a former gypsum mine. The solution of underlying gypsum beds by seepage water can cause a peculiar type of erosion, piping or tunnel erosion. These tunnels, if they eventually become large enough, can collapse and large holes in the ground may result. Even if tunnels do not form, gypsum beds magnify seepage and salinity problems.

The UNDP/FAO studied the following aspects of the problem:

- causes of the present high water table and the possibility of controlling it by groundwater pumping;

- possibility of utilising the groundwater for supplementary irrigation;

- impact of the groundwater situation on possible future development and activities;

- possibility of controlling saline groundwater seepage by means of canals.

The Egyptian Government is in the process of constructing a main collecting drain (due in 1985). A pilot area has been established to study the effects of changing the floor irrigation system to sprinkler and/or drip irrigation.

Introduction of the Nile water further to the west till El-Dhabaa, 150 km west of Alexandria is under way.

In the eastern region, the Sinai Coast, a project is under way to introduce a mixture of Nile and drainage water to the western part of the Sinai coast. A few limited locations are irrigated by surface groundwater. Their production is usually consumed locally.

6.3 Dry farming

Dates, figs and olives are the most common fruit trees in the north coast of Egypt. The three crops together with citrus are well known in the Sinai coast with citrus being grown mainly in Rafah. In the northwestern area palm trees are not common, but figs and olives prevail. In the western region figs occupy the coastal sand dunes as well as further inland, while olives are planted in deep soils between the ridges. Almond and peaches have recently been introduced into the region.

Palm trees are planted in the middle and eastern regions of the coast in the sand coastal strip. The surface is dug down to the moist soil, usually 1 m above the water table. Dates or other vegetables, especially tomatoes or watermelons, are then planted in the moist layer.

Topography is important in selecting the site of groves in the western region. Usually the area surrounded by highland is preferred as it will receive the runoff. In many cases, the farmers construct some form of rainwater storage dug underneath the soil surface. The rainwater is usually directed to this storage and is used as supplementary irrigation during dry summers especially in the first 3-5 years.

Barley is sown in selected areas. The yields are usually low as no fertilisers are applied and the precipitation is low and irregular.

An experiment was carried out to study the effect of supplementary irrigation and fertilisation on the yield of several winter crops (Andel Kader et al., 1984).

6.4 Grazing

The inhabitants of the western and eastern regions of the Mediterranean coast of Egypt are generally Bedouins. They raise sheep, goats and camels. The main edible plants which contribute significantly to the diet of sheep and goats in the western region are *Asphodellus microcarpus*, *Plantago albicans*, *Echiochilin fructicosum* and *Helianthemum lippi*.

Uncontrolled cutting and grazing have generally been blamed as one of the major causes of the degradation of desert ecosystems in this region shown in the reduction of perennial cover, impoverishment of flora, soil erosion, dust storms, formation of mobile sand dunes and establishment of desert pavement. Studies in fenced and free grazing areas had shown that the percentage consumption from shoots by grazing animals was about 20% net primary production in the controlled grazing plots and 40% in the area of free grazing. These studies had also shown that the total digestible nutrients (TDN) in the range ecosystem of El-Omayed site were insufficient for the animals in the free grazing area and were barely adequate for those under a rational system with 50% grazing pressure. The protein content was about 10% less than the desirable level. The micro-nutrients Fe, Zn, Mn and S, were also deficient.

It is not easy to protect productive agricultural land against irreversible loss due to urban and industrial expansion. Several factors aggravate the problem.

(a) The high rate of population increase requires a matching increase in buildings to satisfy the housing requirements of the increasing population.

(b) The Egyptians, for varying economical and historical reasons, usually inhabit the productive Nile Valley and Delta, an area of about 2.6 M ha which constitutes 26% of the total area of the country. Any non-agricultural development thus usually takes place at the expense of productive agricultural land.

(c) The fast rate of increase in population is accompanied by plans of development resulting in expansion of urbanisation and industrialisation.

(d) Land use classification does not solve the problem in the Valley and Delta as most of the lands are productive or could be productive after reclamation.

(e) Land use classification is necessary in the areas of expansion. Areas which were classified "unsuitable for agricultural use" are utilised for constructing new settlements of variable sizes.

(f) Several other factors aggravate this problem in the populated areas of Egypt.

Building materials in Egypt are mainly bricks made of burnt or unburnt clay. The source of the clay is usually the solid sediments of the Nile water during the flood season. After constructing the Aswan High Dam, these sediments are deposited in the lake in front of the dam. The brick industry now depends on removing the top layers of the cultivated clay soil in the Nile Valley and the Delta to varying depths (20-100 cm) to obtain the raw material for its product.

This process deprives the productive land of its highly fertile surface layers. The groundwater mostly about 80-120 cm deep approaches the surface. The hazards of salinisation are thus increased. The area becomes lower than the adjacent land and suffers from seepage of excess water from the higher nearby fields. Such conditions cause waterlogging to take place and in most cases the stripped areas go out of agricultural production.

In order to protect the agricultural land from non-agricultural activities several actions have been taken:

1. The problem was explained and its disastrous effects of agricultural production were publicised through different information media.

2. An act was passed and enforced to prohibit the stripping of productive land.

3. A permit from the Minister of Agriculture was required before establishing any kind of non-agricultural constructions on agricultural land.

Though the rate of taking the arable land out of agricultural use may have slowed down, nevertheless prices offered to landowners were so high that efforts to enforce the above regulation failed.

The pressure of the housing problem and the industrial development activities accentuated the problem not only in the vicinity of the cities but even in the villages.

In 1984 a law was passed and enforced with penalties including imprisonment for committing:

1. Any action which might lead to leaving the agricultural land fallow more than 6 months. It gives the Ministry of Agriculture the right to deprive the owner or the tenant of his right to farm this land and to call in another farmer to utilise it.

2. Any stripping of the land is considered a crime with a penalty of El 10,000 and imprisonment.

3. The present brick factories have to change their raw material and must use materials other than soil. This change should be completed before August 1985 otherwise those factories which have not changed will be confiscated.

4. Any mud bricks for sale or even privately owned after August 1985 will be confiscated.

5. The Public Industrial Sector as well as private investors are encouraged to manufacture bricks made of materials other than soil material.

6. The Cairo Metropolitan area is considered a closed area in respect of further industrial constructions.

7. No non-agricultural constructions are allowed on arable land anywhere in the country. A permit from the Minister of Agriculture and approved by the Prime Minister is required. Aerial photographs have been taken of the cultivated area (2.6 M ha). Any non-agricultural constructions which appear in future photographs will be subject to removal.

8. Because of the fast rate of increase in the population of Egypt and in order to encourage development activities:

   (a) several new towns and settlements have been constructed or are under way, in the desert areas out of the Nile Valley and the Delta, and any new industrial constructions have to be located in these new towns;

   (b) agricultural expansion in the desert areas adjacent to the Valley and the Delta is encouraged in different ways. It is planned to add 1.0 M ha to the amount of cultivated land in the next 20 years. Farmers are encouraged by several methods to move to the settlements in the newly-reclaimed land.

7. PROBLEMS REQUIRING OUTSIDE ASSISTANCE

In an attempt to increase the area of arable land, and to develop stable communities, the Egyptian Government introduced Nile water to desert areas adjacent to the Nile Valley and Delta. It is planned, as stated above, to extend the irrigated area in the western region of the coast to El-Dhabaa 150 km west of Alexandria and to the northwestern part of Sinai. However, the area to be irrigated constitutes a small fraction of the vast Mediterranean coast of Egypt.

Because all significant agricultural activities in Egypt depend on irrigation, dry farming technologies are not common either among Egyptian farmers or agricultural experts. At the same time developing dry farming under such climatic conditions is not an easy task.

Developing dry farming in the Mediterranean coast of Egypt should depend on the utilisation of the scanty rainfall as has occurred in the past. Water conservation practices not only improve the utilisation of the water resources by increasing the recoverable part of the water supplied to the region, but also help to control soil erosion by water in all its forms.

In order to be able to improve rainwater utilisation and apply the measures required to control water flows and floods, it is necessary to have observation data on rainfall distribution and intensity in various regions of the coastal zone. The present observation stations are not only widely scattered, but also fairly near the sea.

The study of runoff conditions has only barely been touched upon. The bulk of the work still remains to be done before a statistical forecast of the flood flows can be drawn up, which is an essential guide in any project to make use of the surface water.

The experience gained in the limited number of experimental stations cannot be generalised. The primary aim of the suggested study programme is to find out suitable ways of increasing the utilisation of the water resources or more precisely to increase the infiltration of water into the soil so that runoff is decreased and plants have more chance of utilising the annual regional water supply. Thus rain-fed agricultural production will become feasible.

The following will be required:

- a better recording knowledge of meteorological data mainly in the form of rainfall distribution data for the whole coastal zone;

- a better knowledge of natural runoff, either in its initial sheet or dispersed trickle form (primary runoff) or in its organised form (wadis);

- a better knowledge of the groundwater reserves that can be tapped, their supply conditions and the most suitable methods of tapping them, allowing for underlying salt water. The role of the groundwater is to guarantee a supplementary irrigation in summer.

The assistance needed to carry out the necessary studies might be as follows:

- supply of the recording equipment necessary for rainfall intensity measurements, the establishment of a climatological observation network inland to complement the limited number aligned along the seashore; the necessary equipment for measuring the total rain in the catchment areas of cisterns, the cisterns water and sediment intake;

- hydrological studies of representing wadis in the region;

- training Egyptian experts to evaluate runoff water and wind erosion, water and soil conservation practices, and dry farming practices.

A proposal was submitted by the College of Agriculture, University of Alexandria, as a maxi-linkage joint project for integrated applied research, demonstration and training in disciplines of development in the north west coastal region of Egypt.

The University of Alexandria Board for Research approved the proposal and requested the Supreme Council of Universities to finance the proposal from the Egyptian-American Universities Co-operation Fund.

The proposal comprises the following:

1. Survey, assessment, conservation and development of resources.

2. Adaptation and demonstration of protective measures against land degradation including sand dune creep, salinisation and over-grazing.

3. Improvement of management practices in rain-fed and irrigated areas including: mechanisation of fertilisation, methods of irrigation, utilisation of brackish waters, introducing highly productive varieties of crops, fruit and vegetables as well as different aspects of animal husbandry which are financially feasible.

4. Experimental utilisation and demonstration of renewable energy resources, mainly solar energy, wind and biogas.

5. Setting up facilities for training technical personnel needed for planning and management of programmes for the sound utilisation of land and water resources in desert regions and other activities.

6. Promotion of the participation of the inhabitants of the region in their community development.

7. Establishing a system or systems for collecting the obtained results and monitoring the effects of development practices on soil and water resources.

8. Dissemination of the findings of the studies by different methods.

9. Exchange of information with other national and international research centres and organisations, especially those concerned with arid and semi-arid regions.

Experience exchange

Because the Mediterranean coast extends thousands of kilometres in several countries with different conditions, the exchange of experiences, knowledge and experimental results is of considerable relevance. This exchange could be achieved as follows:

1. Publication of a specialised periodical and a newsletter.
2. Regular periodical meetings of experts.
3. Holding conferences to which experts from the region and from outside can be invited.
4. Seminars, study groups of experts of similar disciplines.
5. Joint training courses.
6. Exchange visits.
7. Exchange of students for higher degrees.

Assistance which can be sought in Egypt

The writer is of the opinion that, although the rainfed agriculture and soil conservation practices are not well-developed in Egypt due to the conditions set out above, the Egyptian scientists in the following fields have considerable experience:

- desert ecology, especially studies on the Mediterranean coastal desert
- soil science
- hydrology.

The Colleges of Science and of Agriculture, University of Alexandria, have, for a long time, been engaged in studies and research in the Mediterranean coast of Egypt, especially the western regions.

In Egypt there are several periodicals that can be exchanged. The International Agricultural Development Centre, 40 km from Alexandria, offers training courses in various agricultural disciplines attended by trainees from Egypt and several other countries.

8. BIBLIOGRAPHY

Abdel Kader, F., Y. El-Shafei and N. El-Husseiny (1984). Soil Management for Forage and Barley Production under the Rainfed Conditions of the Northwestern Coastal Region, Egypt. EMCIP University Grant Programme (Final Report).

Abdel Samei, A.G., M.A. Abdel Salam and A. Mitkees (1959). Report on the soil survey and classification of Ras El-Hekma with reference to water supply and land utilisation. Desert Inst.Pub., 10:1-33.

Abo-Waly, M.S. (1982). Pedological studies on different salt-affected soils South of Mohite, Drain at Kaft El-Sheikh Governorate. MSc.Thesis, College of Agriculture, Tanta University.

Ali, F.M. (1952). Outstanding variation in rainfall on the North Coast of Egypt. Desert Inst.Pub., 2:5-6.

Ayad, M. (Principal Investigator)(1979). System analysis of Med-Desert Ecosystems of No Egypt.

Ayad, M. (Principal Investigator)(1984). Regional Environmental Management of Med-Desert Ecosystems of No Egypt.

Balba, A.M. and M.M. El-Gabaly (1963). Report on the water supply and land use of Maryut Extension Area. Mem.Report.

Balba, A.M. (1960-1963). Mimeographed reports on soil classification for agriculture utilisation (1) El-Dhabaa; (2) Matrouh; (3) Sidi Barrany.

Balba, A.M. and M.M. El-Gabaly (1965). Soil and groundwater survey for agricultural purposes in the N.W. coast of Egypt. Alexandria University. Res.Bull.Noll.

Dudal, R. (1968). Definitions of soil units for the Soil Map of the World. FAO, Rome.

El-Feel, M.A. and I.M. Fahmy (1972). A study of rainfall and runoff in the Maryut Extension Project Area. Alex. J.Agric.Res., 20:333-342.

El-Gabaly, A.M. (1954). The soils, water supply and agriculture in N. Eastern Sinai. Desert Inst.Pub.No.4, 1:125-153.

FAO (1979). Provisional Methodology for Soil Degradation Assessment. FAO, Rome.

General Company for Res. and Groundwater (REGWA)(1981). Reconnaissance Soil Survey of North Sinai.

General Desert Development Authority (1961). Land development of Western Desert Coastal Zone Reconnaissance Survey. Soc.Gren.D'Etude ET d'Application Hydrol. (SOGRIA).

Kaddah, M.T. (1954). The soils and water supply of Burg El-Arab Farm. Desert Inst.Pub.No.4, 1:161-173.

Kaddah, M.T. (1956). Soil survey of the N.W. Sinai Project. Desert Inst.Pub. No.9.

Lowy, H. (1954). Desert Hydrology. Desert Inst.Pub.No.4, 1:214-219.

Paver, G.L. and J.N. Jordan (1956). Report of Ministry of Public World on Reconnaissance Hydrological and Geophysical observations in No. Sinai Coastal Area of Egypt. Desert Inst.Pub.No.7.

Sabet, S.A. (1961). Soil formation and utilisation of the soils of Wadi El-Arish. PhD. Thesis, College of Agr., Ain Shams University, Cairo.

Shafei, Ali (1952). Lake Mareotis, its past history and its future development. Desert Inst.Pub.No.2, 1:71-101.

Shata, A. (1955). An introduction note on the geology of the northern part of the Western Desert of Egypt. Desert Inst.Pub.No.2.

Shata, A. (1959). Geology and geomorphology of the Wadi El-Kharruba Area. Desert Inst.Pub., 10:91-120.

UNDP/FAO (1964). High Dam Survey FAO/SF : 16 UAR.

PROMOTION OF SOIL PROTECTION AS AN ESSENTIAL COMPONENT OF ENVIRONMENTAL PROTECTION IN MEDITERRANEAN COASTAL ZONES IN ITALY

by

F. MANCINI
Faculty of Forestry
University of Florence
Florence, Italy

1. GENERAL INFORMATION

From the French border to the mouth of the river Magra where Tuscany begins, the Ligurian coast is rocky and steep except for a few narrow valleys dissected by short rivers or torrents descending from the mountains immediately behind.

Though the coasts of Tuscany and Latium are generally flat, there are no extensive plains apart from those of the Arno and the Tiber. Some promontories face the sea, such as the mountains of Leghorn, Piombino, l'Uccellina, the splendid Argentario and La Tolfa. Between Rome and Naples the Circeo extends to the sea.

There are mountain ranges close to the sea standing above the coast like the Apouanes Alps and much further south the Volcano Laziale, the Ausoni and Aurunci. Around Naples, the Somma-Vesuvio and the Campi flegrei, both volcanoes, characterise one of the most famous landscapes of the world.

South of Torrento the coast remains rocky through the whole of Calabria, interrupted by a few small plains and one large littoral plain, Battipaglia. However, a narrow flat strip does exist in many places.

The Lucanian coast, the well-known Metaponto, is a rich flat littoral where there is high-quality agriculture and horticulture. Apulia has generally rocky coasts except north of Bari near the mouth of the Ofanto, and in the Tavoliere as far as the Gulf of Manfredonia. From the Gargano promontory to the south of Pescara, the coast is rocky. From there to the Mount Conero near Ancona it is flat with a long series of near-parallel rivers, some of local origin, the majority rising in the Appennines. High snow-covered mountains such as the Majella and the Monti della Laga stand near the Adriatic Sea.

From Ancona to Pesaro sandy hills dominate the coastline. Further north the littoral is flat as far as the Po delta and the mouths of the Adige, Piave and Tagliamento in the Gulf of Venice. At Trieste, at the Yugoslav border, the coastline becomes rocky once more.

The coastal zones of our major island, Sicily, have some important plains like those of Catania and Licata, but are generally rocky or with only a narrow ribbon of alluvial or coastal sediments. High mountains stand near the littoral like Etna, the largest volcano in Europe, still occasionally active. Sardinia has a few plains called "Campidani" but is mainly mountainous.

Over 9,000 kilometres of Italian coastline display a wide variety, from large gulfs to tiny bays, from sandy beacnes to steep cliffs. Undulating or steep cliffs are usually quite close to the sea, and therefore there are many existing problems of soil erosion while others are in the offing.

The coastal zone of Italy generally enjoys a rather mild Mediterranean climate, but since it is a narrow strip some nine thousand kilometres long, there are considerable overall differences. For instance, if we compare the "riviera ligure" west from Genova, and the coast around Trieste, we note that the wind regime is quite different. In fact the Ligurian coast is protected by the maritime Alps and the preappennine mountains from the northern winds while Trieste often suffers from the tremendous "Bora" gusting down the northeast at high speed (sometimes more than 100 km/hr).

In the major islands of Sicily and Sardinia, the influence of the Mediterranean Sea is much stronger than in the two areas mentioned above. In the islands the winters are milder and warmer and the summers hotter. African winds may blow for two or three days, carrying a noticeable amount of fine reddish or yellowish sand coming from the African deserts.

In Table I, the temperature regime for some typical localities is summarised.

Table I

Temperatures of some typical localities in the coastal zone of Italy

Station	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
Trieste	5.3	4.8	8.6	12.9	17.1	21.2	24.0	23.8	20.8	15.6	12.0	6.3	14.3
Ancona	5.7	5.8	9.4	13.5	17.6	22.3	21.9	24.3	21.1	16.6	12.6	7.4	15.1
Lecce	7.8	8.4	10.8	14.2	18.4	22.7	25.5	25.2	22.6	18.6	15.0	10.5	16.7
Palermo	10.3	10.4	13.0	16.2	18.7	23.0	25.3	25.1	23.2	19.9	16.8	12.6	17.9
Cagliari	9.9	10.3	12.9	15.3	18.6	22.8	25.8	25.7	23.3	19.5	15.6	11.8	17.5
Napoli	8.7	8.7	11.4	14.3	18.1	22.3	24.8	24.8	22.3	18.1	14.5	10.3	16.5
Roma	7.4	8.0	11.5	14.4	18.4	22.9	25.7	25.5	22.4	17.7	13.4	8.9	16.3
Viareggio	9.1	9.4	10.3	13.4	17.1	20.5	23.1	22.8	21.2	16.8	12.5	9.1	15.4
San Remo	9.7	10.0	12.1	14.4	17.6	21.2	23.4	23.7	21.8	17.9	14.1	11.0	16.4

Precipitations occur mostly as rain in the littoral regions of Italy but snow may occur anywhere. In the severe winter of 1984-85, Naples and Palermo were covered by a snowfall which of course quickly disappeared. On the other hand, in Trieste, snowfalls are quite frequent, and the snow lies for one or two weeks.

The amount and distribution of the rains during the year differ according to latitude and the presence of mountains along the coast or the immediate hinterland.

Table II shows some characteristics of several stations along the coast or 15-20 kilometres in the interior. A few localities in the interior near the boundary of the coastal zones have been included in order to emphasise the consistent differences occurring over a relatively small area. Another important feature of the rainfall is its intensity but this will be dealt with in the chapter concerned with water erosion.

Table II

Rainfall in some typical localities of the Italian coastal zone or immediately in the interior

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Year
Trieste	57	48	80	104	87	77	57	83	120	112	125	65	1015
Ancona	68	39	46	57	50	51	28	31	59	101	62	51	643
Lecce	74	58	57	37	28	30	7	19	42	69	98	99	518
Palermo	141	129	89	65	32	16	6	29	54	123	99	179	962
Cagliari	54	59	50	43	39	5	3	10	32	53	57	74	479
Napoli	87	77	76	55	37	33	14	16	56	102	135	105	793
Avellino	124	152	130	135	63	58	26	25	61	116	199	146	1235
Roma	74	87	79	62	57	38	6	23	66	123	121	92	828
Grosseto	65	57	56	54	51	26	13	21	48	98	93	78	660
Massa Marittima	81	71	68	63	74	47	23	40	79	121	126	106	899
Viareggio	96	96	87	90	86	32	20	28	70	84	125	92	906
Lucca	121	109	105	95	101	62	32	46	95	167	164	139	1236
San Remo	67	56	61	56	46	22	14	27	47	88	93	101	678

The soils of the studied regions may be included in several orders or classes of any chosen classification.

At the Congress on the Mediterranean soils held in Madrid and Lisbon in 1966, I proposed the elimination of the term "Mediterranean" from soil classification because it was misleading. I demonstrated that the soils present in this area may be classified under at least six or seven orders of the American Soil Taxonomy.

As far as Italy is concerned, in 1967 I, with many co-workers, published a soil map on a scale 1:1.000.000, along with an explanatory text. A copy of that map is attached to this report. That map was the Italian contribution to the FAO soil map of Europe on a scale 1:2.500.000, published in 1965. Much work has been accomplished since the 60's and now after almost twenty years, a new map on a scale 1:1.000.000 of the nations pertaining to the European Community is in press and will be available in a few months. A team of Italian soil scientists has prepared our national contribution. This includes, especially in the Mediterranean zones, some new soil associations and a considerable increase in detailed delimitation. It is a matter of fact that in these regions many good detailed soil surveys have been carried out by the Universities and other scientific bodies. The improvements are

particularly evident in the case of many coastal zones. Typical examples are the new maps of Sardinia (A. Aru and others) and of Sicily (G. Fierotti and co-workers). All the recent soil maps and pedological documents include, as far as classification is concerned, clear correlations with regard to Italian definitions, French classification, the American Soil Taxonomy and the FAO/UNESCO Legend. In addition, in many cases interesting derived maps have been prepared for different purposes.

To summarise: there is in the plains the obvious presence of alluvial soils of different texture and drainage classes (Entisols or Fluvisols) but in the neighbouring hills large areas are covered by Inceptisols (mainly Ochrepts and Humbrepts. Alfisols, probably the most typical zonal soils of the Mediterranean, are widespread. They may be found in Pleistocene fluviatile terrasses (Haplo and Palexerals) or on hard mesozoic or palaeozoic limestones (Rhodoxeralfs, the world-famous "terra rossa"). Vertisols (the old black Mediterranean earth rich in swelling clays) are present in flat or gently undulating terrains while Mollisols frequently occur under remnants of the old "Silva Mediterranea", the forest dominated by Quercus ilex, one of the evergreen oaks. Ultisols are less common but appear on old surfaces both on solid rocks and alluvial sediments with poor parent materials. Thus the soil itself, the fundamental resource for human beings, shows in the coastal zone of Italy a tremendous variety of types.

The vegetation of the Italian littorals is strongly influenced by a long-lasting and severe anthropic activity. A high percentage of these regions was already cultivated before the arrival of the Greeks in the south and in Sicily, before the presence of the Etruscans and the Romans along the Thyrrenian coast. The late Neolithic inhabitants of the Gargano in Apulia were most probably farmers, and consequently human pressures on the vegetation cover has been very extensive.

The natural vegetation of the coastal zone according to the Italian phytogeographers (Giacomini, Fenaroli, Tomaselli, Pignatti et al.) is represented by two main associations. In the more arid and warmer belt the Oleo Ceratonion association prevails. Its name derives from the wild olive tree (Olea europaea subsp. oleaster) and the Carob tree (Ceratonia siliqua) which are the dominant species accompanied by shrubs like the Mirth (Myrtus), the Tamarisk (Tamerix) and tall herbs such as Ampelodesma mauritanica which is also present in North Africa on the coasts bordering the Mediterranean Sea. This association is undoubtedly very xerophilous.

The other association is the Quercetum ilicis that can be found in the more humid and protected situations facing North or on deep soils rich in organic matter with a favourable water regime. The Holly Oak is generally accompanied by a group of minor trees like the bay laurel (Laurus nobilis), the strawberry tree (Arbutus unedo), the buckthorn (Rhamnus alaternus), the terebinth (Pistacia therebintus and Pistacia lentiscus), the azarole (Phyllirea sp. pl.).

There are also pine forests along the Italian coasts. The aleppo pine (Pinus halepensis) and the umbrella pine (Pinus pinea) flourish on warmer sites up to 300 or 400 metres while the maritime pine (Pinus pinaster) can be seen as a pioneer species climbing up to 700-800 metres in the slopes facing the sea.

Many papers have been published recently with maps of Mediterranean vegetation, from which I will refer only to the excellent outline of the vegetation of Sardinia by Pier Virgilio Arrigoni. From the photoclimatic point of view, A. de Philippis and R. Gaussen had already prepared many years ago, a map for FAO which showed the distribution of Mediterranean vegetation in Europe.

Both past and present land use will be illustrated in other chapters of this report. Before closing this short summary of general information on the coastal zones of Italy, it is important to record that we have only recently received many fine contributions providing information on the evolution of the littorals. In a few weeks an Atlas of the Italian coasts with legends also in English will be available. It has been prepared over the past decade by a large team of specialists under the excellent guidance of Giuliano Fierro within the framework of the finalised project for soil conservation of the Italian Council of Research directed by the present rapporteur.

2. SOIL EROSION

In the coastal zones of Italy, though water erosion is dominant, wind erosion is certainly not absent. Sheet erosion is widespread especially in the cultivated areas which have long and gently sloping fields. This kind of erosion is difficult to demonstrate because any such evidence disappears when the farmer ploughs the land. Nevertheless the danger and the damage do exist. Rill erosion where the slope is steeper and terracing has not been adopted. Deep gullies can be observed in several geolithological formations. Erodibility of our grayish-bluish marine pliopleistocene silty clays is well known. Characteristic examples are observed in Emilia, in Tuscany near Volterra and South of Sienna in the so-called "crete", in Abruzzo and in Calabria. Gullies occur also in sandy incoherent soils and in the volcanic districts when fine ashy piroclastic materials outcrop. In these formations the gullies often have almost vertical walls.

In many localities where there is severe erosion, mass movements also occur of a variable nature, dimension and age. Fall, sliding and flowing phenomena are recurrent but very old movements ("paleofrane") are often rejuvenated.

Recent papers on soil erosion by means of water deal generally with two main aspects. The first is the study for the improvement of the methods used for a better comprehension of the influence of the various factors on soil erosion. The second is the experimental approach with the aim of establishing the risks presented in hilly landscapes by the various soils, not only classical experimental fields but also simulations of rains of variable intensity in different soils, mostly in sub-littoral areas in South Italy and the islands.

It is clear from this research that the selectivity of erosion provokes extensive damage in many areas. The finest particles of clayey deposits or soil rich in organic matter are rapidly washed away. In addition, transport of coarser materials occurs in riverbeds especially in the upper part of the catchments. This phenomenon is particularly evident in the wild torrents of Calabria (the "fiumare"). To get a better idea, we have compared aerial photos taken in 1955 with those taken twelve years later. In many valleys the accumulation of coarse gravels and cobbles in this short period was very

intense. An average of half a metre per year is quite common. This brings about considerable morphological modifications with the riverbeds suspended on the adjacent plains.

Italy has a long tradition of public works for river control and struggles to control and contain flooding. Apart from these hydraulic engineers, agronomists, especially in Central Italy, were already in the XVIII and XIX centuries sufficiently skilled to build terraces, simple walls and other distinctive systems for regulating runoff and impeding severe erosion.

Why is there such intense erosion in Italy and a consequent deep interest in applying different series of methods to reduce it?

There are some natural but also many anthropic causes. First of all there is the unfavourable distribution of rainfall in many regions, and its high intensity. One remarkable example will be sufficient. For many years in Calabria huge amounts of rain have been measured. Often precipitations have a long duration, 4 or 5 days, and therefore 300 and 400 mm in 24 hours is not uncommon.

This very high intensity occurs not only in the coastal zones but also in the nearby mountains. Where steep slopes and unfavourable geological and morphological conditions prevail, rapid and massive transport of very coarse material is the rule.

It is not easy to maintain a struggle against phenomena of this kind. Reafforestation, elimination of overgrazing, dams and longitudinal works along the wild torrents have been carried out but when the amount and the intensity of precipitations is very high the results are not very satisfactory.

Forest fires are both frequent and dangerous in the Italian coastal zones, occurring mainly during the winter months in Liguria and Northern Tuscany, generally during sunny days with strong winds blowing from the North. However in the "Maremma tosco-laziale", in the south and in the islands, the fires are more frequent in summer. There are noticeable differences from year to year. For instance during 1983 it was very hot and arid in July, whereas in 1984 more rain fell and the weather was fresher, with fewer fires.

According to the Italian constitution, regional administrations have almost total control of agriculture and forestry. Therefore, they have organised a defensive system against this severe attack on natural vegetation. Also, in the more delicate areas, cultivated fields, farmers' houses and touristic villages are endangered. Each region has a different organisation. In the Alps every village has a well prepared team of firemen. In large towns many groups of volunteers exist, who work together in naturalistic or ecological societies. The Ministry of Agriculture and Forestry has a battalion of well prepared and equipped specialists who can help rapidly in the most difficult situations. In certain cases the Army is also available.

It must be admitted that the battle can also be lost despite good organisation and goodwill. In 1983, even with the aid of aeroplanes, helicopters, and jeeps, the regional authority of Sardinia was only able to cope with some 8-10 out of the 50-60 fires which occurred every day.

In the coastal zones we have abandoned agricultural land only where cultivation is too difficult or really is not economically feasible. The Ligurian steep slopes facing the sea and densely covered by olive trees and xerophilous shrubs, are certainly a permanent source of wild fires which are not easy to control due to the unfavourable wind regime.

3. ABANDONMENT OF AGRICULTURAL LAND

The question of abandoned land in a hilly and mountainous country like Italy which has rather poor soils, is without doubt a very delicate one. In my opinion the abandonment is in many cases justified. When the terrain is too steep and/or the soil too shallow, erodible and infertile, the return of the forest is inevitable, as, in the instance quoted above, of the slopes of Liguria, with high walls which separate narrow fields called "fasce" (strips) and, accordingly, have been abandoned. Nearby, where slopes are not so steep and there is water available, there can be observed gardens, nurseries, and many other activities carried out by well-prepared specialists, which have excellent economic results. In many localities this is closely connected with an old-established international touristic activity with splendid attractions. There are thus strong differences within a distance of less than one kilometre.

In our southern regions many areas were reafforestated after the second world war, and there is reason to believe that this was an excellent programme. Some of these new woods have already begun to give good timber and already protect the soils and improve their fertility.

Recently several good laws have been enacted providing substantial aid to people living in the mountains. Many rehabilitation works have also been proposed. The State has purchased thousands of hectares creating new public forests. Agriculture and animal husbandry remain in favourable conditions only in large farms with sufficient land at least of medium quality. These problems are of course more widespread in the interior than in the coastal zones.

4. SUBSIDENCE IN THE RECENT ALLUVIAL PLAINS

The coastal sand dunes generally covered by forest, particularly pine forest. Most of the alluvial plains behind the coast were reclaimed in the last centuries, filling the depression with the method called "della colomata". This consists in raising a tract of land which then forces river waters with a high amount of suspended materials to enter the depression and remain there. All the materials will sediment and from year to year the level of the land will gently rise.

In many of the recent or actual alluvial plains there are severe problems of subsidence. The situation of Venice is well-known and many international authorities have become involved in the rehabilitation enterprises. In many other coastal plains there are similar phenomena. Near Ravenna in the late 70's the level of the land fell by 1 cm per year in large areas and by 4-5 cm/year in more restricted areas. This was due to natural subsidence and the consolidation of very fine silty-clayey materials. Moreover these areas were full of heavy industrial buildings full of machines, raw materials and finished products. The pumping of water and gas from deep tables was another

reason. Due to the fall in the level of the land, in many cases hydromorphism in the lower soil horizons increased rapidly; in other areas superficial stagnation occurred for long periods during the wet season. For this reason some areas were abandoned. Reclamation is certainly not easy but attempts were made, pumping fresh waters from the rivers in several deep water tables, and this had good results.

Another danger in these coastal areas suffering subsidence is the influx of salty waters from the sea. The presence of high quantities of sodium provokes the deflocculation of the clays which lose their consistence completely. Of course these tracts of land were also abandoned.

5. LOSS OF GOOD AGRICULTURAL LAND

A most difficult question everywhere is the continuous loss of very good soils in the vicinity of large and small towns. Urbanisation has always been and still is very intense. The principal reasons for this are:

(i) loss of interest in agriculture and subsequently more people take up employment in industries, commercial and tertiary activities;

(ii) new industries are established in the coastal zones;

(iii) there are increased possibilities for many people to buy a flat in town, and often have to sell the old farm;

(iv) migration of retired people to coastal areas with a milder climate rather than in the interior (from Piedmont and Lombardy versus Liguria);

(v) building along the littoral of so-called "seconde case" (second houses) for holidays and/or renting;

(vi) increase in the construction of hotels, pensions, restaurants and other touristic facilities mainly for foreigners (in Romagna especially for German-speaking people), and in other localities also, for the Swiss and the Swedish.

It is rather difficult to have up-to-date information on this latter problem. We know that we have lost many hundreds of thousands of hectares in the last twenty years. Of course this is not only an Italian problem but a general phenomenon throughout the world, as well as in the emerging countries.

For our coastal zones a typical example is the "Riviera romagnola" where we have a "conurbation" which comprises a strip of houses 50 km long, uninterrupted except for little gardens and urban parks.

In many other cases as in Rome, Naples and Palermo, the best soils in the surrounding areas were lost when industries came and houses were built for residence.

Attached to this report is a map of the city of Cagliari, the capital of Sardinia, presented by Professor A. Aru and co-workers at an international Congress held in Berlin on this subject. It demonstrates to what extent soils have been lost during the present century. It is a good example of careful

research, incorporating aerial photographs of different ages and making use of an interdisciplinary approach of scientists of various disciplines and humanists such as historians, sociologists and so on.

The preparation of good land capability maps is very important. These documents are valuable tools in the completion of an improved plan for the urbanisation of delicate areas. Soils of Class 1 or 2 must be preserved for agriculture while soils of the lower classes may be destined for other uses. We have to convince urbanists, architects and other planners of the utility of such documents. On our part we have to prepare clear, concise and simple legends which enable the decision-makers to easily understand the issues. With such maps some good results have been already achieved especially in Piedmont (surrounding areas of Turin, Mondovi, etc.). Not much was obtained in the coastal zones. In the south especially, many illegal dwellings along the shore were constructed, without permission, and now a new law allows their regularisation upon payment of a moderate fine.

In Italy this extensive loss of good soils is also due to the absence of a national soil survey capable of indicating, when requested, the most suitable soils for each separate use. Another reason is that the urbanisation plans were in general prepared by architects who do not know how to operate pedology, geomorphology, phitogeography and other basic disciplines.

6. ACTUAL PROBLEMS IN THE COASTAL ZONES

After this short description of some of the larger issues it is useful to summarise the main problems faced by Italian scientists and technicians.

(i) The existence of a very large coastal zone, almost one third of the entire national territory which results in many thousands of kilometres of littorals to survey and systematically control.

(ii) There is a dense population in most of these zones, and both large and small towns are rapidly increasing.

(iii) There is great anthropic pressure in many localities during the touristic season, not limited to summer but may include spring (Easter holidays) and in the south a long and mild autumn. Both foreigners and Italians constitute a gigantic army of millions of people moving against nature whose impact cannot be underestimated.

(iv) Along the coasts in many localities there is severe marine erosion and consequent littoral regression.

(v) Many rivers entering the Italian seas no longer have a natural regime but have been strongly modified by human activity. Actual discharges and loads are quite different from past ones. The transport of solid materials to the mouths and into the sea is much less than 30 years ago and therefore most of the littorals are no longer enriched with new pebbles and sand.

(vi) Many of the socio-economic problems make the solution of regional or local situations very complex. Science and technique often cannot overcome political factors.

7. POSSIBLE EXCHANGE OF EXPERIENCES

The exchange with other nations of the Italian experiences in the coastal zones will certainly have great interest for all of us. On our part, I think that many institutions working in quite different fields will be happy to have such exchanges quoted. Those institutions that follow are near to my field of experience so the humanities and the socio-economic sciences are rather weakly represented.

The first agency is the Italian National Council of Research, organised in several specific committees for different groups of disciplines (for instance Com. for geomineralogical sciences, C. for agricultural sciences). This Council directs and finances scientific research with its own institutes and centres and helps the universities and other State institutions (i.e. Agricultural Experimental Institutes).

In our field of interest the C.N.R. has three Institutes for hydrogeological protection, and many centres having university facilities. Among those centres, those concerned with soil genesis, classification and cartography founded and directed by myself may be noted.

Italy has many universities, running from ancient establishments like Bologna, Padova, and Pavia to the brand new (Lecce, Potenza, Reggio Calabria).

Research into Italian problems has been conducted with the publication of hundreds of papers and much is still in progress in many faculties. In recent years the interdisciplinary approach and a common language among scientists of very different origins and preparation may be considered as an excellent result from our point of view.

UNESCO has three important institutions under the umbrella title of "Mediterranean Agronomic Institute". Their seats are respectively Bari, Montpellier and Saragoza. All are carrying out research in the Mediterranean area and in the emergent countries.

The Ministry of Agriculture and Forestry among its 23 experimental institutes has some which are rather important for our purposes: the Institute for Soil Study and Conservation in Florence, the Institute for Forestry in Arezzo while in Bari there is the Agronomic Institute and in Rome that for plant nutrition. These bodies are organised with a central station and some peripheral sections situated in strategic localities for each specific field of scientific activity. All the institutes have continuous and cordial connections and collaboration with many similar foreign institutions.

The State has also some national services working in the field from the past, among these the Geological Survey, which was founded more than 110 years ago, and the Hydrographic Service, both operating also in the coastal zones. A soil survey and an agency studying the vegetation still do not exist. For the time being, it must be stressed that all of these services are under-staffed and under-funded. This entire sector must be reconsidered by Parliament. A book on how to rehabilitate the State services has been recently published by the National Council of Research. Only with major changes will these agencies constitute a useful instrument in land planning and rehabilitation.

Due to the lack of assistance from the State, Regional Administrations have founded Regional Offices. Examples are the regional geological office for Piedmont or that for Sicily, and a multidisciplinary cartographic service in Emilia-Romagna. Other regions have a different approach or show less interest in these problems.

As far as the basic cartography is concerned two State institutions work in the coastal zones and have useful links with similar bodies of other Mediterranean nations. The IGMI (Istituto Geografico Militare Italiano), situated in Florence, has the job of preparing the basic topographic maps and other documents at different scales (100.000; 250.000; 500.000; 1.000.000). It is now finishing the 1:50.000 map and considering the possibility of bringing up to date the old 1:25.000. The other office is the IIM (Istituto Idografico della Marina) which surveys the sea bottom and controls the variations of the harbours and the coasts. It gives daily announcements of great use to mariners.

It is the opinion of the rapporteur that all the above-mentioned Italian institutions already co-working with foreign agencies could in the near future increase this collaboration with reciprocal advantage.

8. SOME FINAL PROPOSALS

Exchange of experiences among the Mediterranean countries may be pursued in many ways. There are already, for instance, bilateral agreements between the National Council for Research and similar organisations of many nations also in the Mediterranean basin. These exchanges are generally limited both in the number of the visiting professors and in the financial aid for scientific research conducted in collaboration. These programmes could be improved by providing a special section for soil protection or more generally for the protection of the environment.

The above-mentioned State services (geological, hydrographic, cartographic, etc.) existing in every country may be put in readiness to prepare common programmes of activity, including the nomination of liaison officers.

The Ministers of Scientific and Technological Research, of Ecology or Environment, of Agriculture and Forestry could meet and verify, with the support of the European Community, how feasible are international projects of research, common controls on delicate questions or at least similar lines of action in each country.

Scientific societies, ancient academies, museums and other bodies of the same nature, may easily work together or organise systematical and fruitful exchanges of ideas, experiences and programmes, without extra finance being provided.

In my opinion there many possibilities for common activities, and their success depends on the good will of all the participants.

CONCLUSIONS AND RECOMMENDATIONS OF THE WORKING MEETING OF EXPERTS ON THE PRIORITY ACTION ENTITLED "PROMOTION OF SOIL PROTECTION AS AN ESSENTIAL COMPONENT OF ENVIRONMENTAL PROTECTION IN MEDITERRANEAN COASTAL ZONES" HELD IN THE PREMISES OF PAP/RAC,

SPLIT
25-27 November 1986

1. The Mediterranean coastal zones suffer, to a higher or a lesser degree, from all types of soil degradation (runoff erosion, wind erosion and seawater erosion; secondary salinisation and sodification due to irrigation; and loss of productive land to non-agricultural uses). Governments of Mediterranean countries and their local authorities must be aware of the fact that soil is a natural resource which the existence of their peoples depends on, and that its degradation affects the equilibrium of the entire ecological and socio-economic system of the coastal zones.

Despite the differences of their natural conditions, historic and socio-economic development, the problems pertaining to soil protection are of common importance to the majority of Mediterranean countries, their solution being a joint concern and task. That is where international co-operation is necessary and beneficial, particularly for developing countries in their effort to protect and enhance the quality of the Mediterranean environment.

Although there is sufficient knowledge and viable technical solutions in the region, various economic, social and sometimes political constraints hinder their application. It is, therefore, necessary to understand and consider these constraints and to investigate and recommend ways of overcoming them. To make soil conservation acceptable to farmers it must be linked to increased production while at the same time maintaining or increasing soil fertility and arresting erosion.

2. The erosion phenomena are a major cause of soil degradation. It is therefore recommended that on this priority problem a joint Mediterranean co-operative action be immediately prepared and launched. The preparatory activities should preferably be jointly undertaken by PAP/RAC, FAO and ACSAD.

One of the fields of future Mediterranean co-operation should be the preparation of an overall survey of watersheds in the coastal Mediterranean zones, and a classification of soil erosion phenomena should conform to a uniform methodology.

3. Recognising that the loss of agricultural land to non-agricultural uses has become an acute problem of common importance to the countries of the region, the meeting recommends the following to be carried out:

- a factual evaluation of the problem in each country;
- measures and legislation to protect the agricultural land from being lost to non-agricultural uses, keeping in mind that combating the problem requires alternative options to meet the needs of the increasing population in the region, as well as taking into account the fact that gaining public support and understanding of the problem gives the protective measures a better chance to be enforced;

- a document containing a survey of policies and legislations relevant to the protection of agricultural land from non-agricultural uses, and a summary of various experiences in the countries of the region;

- incentive measures to encourage the installation of industries providing employment in the coastal hinterland, which will thereby help to arrest the permanent drain of its population and the controlled urbanisation of the coastal areas.

4. Salinisation and sodification are the problems faced by many countries of the region. It is therefore recommended that an evaluation of the magnitude of these problems be made in each country specifying areas already affected by, as well as those vulnerable to, salinisation and sodification, and analysing the causes and the effects of the phenomena on soil productivity.

5. Recognising that the execution of such a programme requires considerable expenditure and a high-level expertise, the meeting proposes that co-operation and financial support be sought from national governments of the region and international organisations and agencies, especially of FAO, UNDP, EC and ACSAD.

6. The meeting determines that the training of specialists should be given particular attention, and strongly emphasises the need for establishing a library which would collect, store and disseminate information on various activities in the field of soil policies and soil management practices.

7. Recognising that river deltas and some sections of the coast are composed of soft sediments and that beach erosion is a serious problem, the meeting proposes that an evaluation of this phenomenon in the region be made through a case study.

8. Recognising the essential role of climatological records, the meeting concludes that the countries of the region should be urged to establish an efficient network of recording stations since the data so obtained constitute the basis for understanding the soil degradation processes.

9. Recognising the importance of the role of forests in maintaining the ecological equilibrium and particularly the conservation of soils, the meeting feels that special attention should be paid to deforestation problems in Mediterranean coastal zones, and recommends:

- that immediate measures be taken with a view to resolving the problem, particularly on the technical and socio-economic plane; and

- that an efficient international assistance be secured for those countries which have recognised the need for a continuous effort against deforestation as a matter of priority concern in the domain of soil conservation.

10. A frequent phenomenon in Mediterranean coastal zones is the number of devastating forest fires caused or stimulated directly or indirectly by a rapid development of economic activities, especially tourism; by an excessive increase of population in coastal zones; by poor maintenance of woodlands; and, finally, by a lack of adequate fire prevention and protection.

Recognising that forest fires are one of the major causes of soil erosion and environmental degradation of Mediterranean coastal zones, the meeting recommends that, at the initiative of MAP/PAP, Mediterranean Governments should explore the possibilities of launching and carrying out a separate project of Mediterranean co-operation on the protection of coastal zones from forest fires.

11. The meeting recommends that Governments of the region undertake necessary actions with a view to increasing public awareness at all levels (general public, decision-makers, specialists) about soil degradation problems.

12. Education and training of professionals in soil and water protection and conservation should be given special attention. The meeting thus recommends that: (a) special courses for undergraduates be organised at the universities and schools; (b) fellowships for the students from the region be granted; (c) exchange of visits of experts among Mediterranean countries be secured; (d) periodical workshops for the experts be held to discuss and exchange experiences on various subjects of soil degradation and protection; and (e) training courses for specialists be organised on selected subjects, such as water and wind erosion, soil salinity and sodicity, sand dunes stabilisation, water conservation practices, forest management, etc.

CONCLUSIONS ET RECOMMANDATIONS DE LA REUNION DE TRAVAIL D'EXPERTS CONCERNANT L'ACTION PRIORITAIRE INTITULEE "PROMOTION DE LA PROTECTION DU SOL EN TANT QUE COMPOSANTE ESSENTIELLE DE LA PROTECTION DE L'ENVIRONNEMENT DES ZONES COTIERES DE LA MEDITERRANEE", TENUE DANS LES LOCAUX DU CAR/PAP,

SPLIT
25 - 27 NOVEMBRE 1985

1. Les sols dans les zones côtières méditerranéennes sont exposés, bien sûr à des degrés différents, à toutes les formes de dégradation (érosion hydrique, marine et éolienne, salinisation secondaire et sodification dues à l'irrigation et perte des terres fertiles au profit de l'utilisation non agricole). Les gouvernements des pays méditerranéens ainsi que les autorités locales doivent prendre conscience du fait que le sol est une ressource naturelle dont dépend l'existence de leurs peuples et que la dégradation du sol bouleverse profondément le système écologique et socio-économique dans les zones côtières.

Nonobstant les différences sur le plan des conditions naturelles et du développement historique et socio-économique, les problèmes liés à la protection du sol préoccupent avec la même importance la majorité des pays méditerranéens et la recherche des solutions à ces problèmes doit être leur tâche commune. C'est pourquoi il est nécessaire de développer une coopération internationale qui serait particulièrement profitable aux pays en voie de développement dans leur effort de protéger et améliorer la qualité du milieu méditerranéen.

Bien qu'il existe dans la région méditerranéenne suffisament de connaissances et solutions techniques viables, différentes contraintes d'ordre économique, social et parfois politique rendent impossible leur application. Pour ces raisons, il est nécessaire d'examiner et de chercher à comprendre ces contraintes pour pouvoir recommander la façon dont elles devraient être surmontées. Pour que la conservation des sols soit acceptable aux cultivateurs, elle doit être étroitement liée à l'accroissement de la production et en même temps se soucier de maintenir ou d'augmenter la fertilité du sol et de freiner l'érosion.

2. Le phénomène d'érosion est la cause principale de la dégradation du sol. Il est recommandé de préparer et lancer immédiatement une action coopérative au niveau de la région, visant à remédier à ce problème. Une des activités à entreprendre dans le cadre de la future coopération méditerranéenne est l'élaboration des relevés des bassins versants et la classification des phénomènes d'érosion en appliquant une méthodologie uniforme.

3. Ayant identifié la perte des terres agricoles fertiles au profit de l'utilisation non agricole comme un problème aigü et commun aux pays de la région, la réunion a recommandé ce qui suit:

- évaluation de ce problème dans chaque pays individuel;

- prise des mesures légales visant à protéger les terres fertiles contre l'utilisation non agricole, tout en tenant compte du fait que la lutte contre ce problème requiert des solutions alternatives pour répondre aux besoins de la population toujours croissante et que la sensibilisation du public de ce problème rend plus facile la mise en application des mesures de protection;

- élaboration d'un document contenant un aperçu des politiques et législations relatives à la protection des terres fertiles contre l'utilisation non agricole, et un sommaire de diverses expériences acquises par les pays de la région;

- prise des mesures incitatrices favorisant l'installation de l'industrie génératrice d'emplois en dehors des zones côtières pour les soulager d'une émigration permanente, et par conséquent, d'une urbanisation sans limite.

4. La salinisation et la sodification sont deux problèmes rencontrés dans la majorité des pays méditerranéens. Il est recommandé d'évaluer l'importance de ce problème dans chaque pays, d'identifier les zones déjà affectées ainsi que celles qui sont particulièrement vulnérables à la salinisation et la sodification, et d'analyser les causes et les effets de ce phénomène sur la productivité du sol.

5. Vu que la mise en oeuvre d'un tel programme requiert des dépenses considérables et des expertises de haut niveau, la réunion a proposé que soient demandés la coopération et le support financier des gouvernements des pays de la région, et des agences et organisations internationales, notamment de la FAO, de l'ACSAD et de la CE.

6. Une attention particulière devrait être accordée à la formation des cadres. La réunion a souligné la nécessité de créer une bibliothèque qui pourrait collecter, stocker et disséminer les informations sur diverses activités dans le domaine des politiques foncières et des pratiques de gestion des sols.

7. Etant donné que les deltas de fleuves et certaines sections de la côte sont constitués de sédiments tendres et que l'érosion côtière constitue un problème sérieux, la réunion a proposé que soit effectuée une évaluation de ce phénomène, ceci à travers des études de cas.

8. Ayant en vue le rôle essentiel des données climatiques, la réunion a conclu que les pays de la région devraient établir un réseau efficace de stations de recherche. Les données ainsi recueillies seraient une bonne base pour comprendre les processus de dégradation des sols.

9. Vu l'importance des rôles des forêts dans le maintien des équilibres écologiques et tout spécialement dans la conservation des sols, il est souhaitable qu'une attention toute particulière soit accordée aux problèmes de déforestation en zone côtière méditerranéenne. A ce propos, les experts ont recommandé:

- que des mesures immédiates soient prises en vue d'approcher ce fléau, notamment sur les plans tant technique que socio-économique;

- qu'une aide efficace des instances internationales soit accordée aux pays qui éprouvent le besoin de retenir la lutte contre la déforestation comme l'une de leurs priorités en matière de conservation de sol.

10. Un phénomène fréquemment rencontré dans les zones côtières méditerranéennes constituent les incendies de forêts provoqués directement ou indirectement par le rapide développement des activités économiques, en premier lieu du tourisme; par l'accroissement excessif de la population en zones côtières; par le manque de soin pour le couvert forestier; et finalement, par le manque de mesures adéquates de prévention et protection contre les incendies de forêts.

Vu que les incendies de forêts sont une des causes principales de l'érosion et de la dégradation des sols dans les zones côtières de la Méditerranée, la réunion a recommandé qu'à l'initiative du PAM/PAP les gouvernements des pays méditerranéens explorent les possibilités de lancer et mettre en oeuvre un projet particulier de coopération méditerranéenne en matière de protection des zones côtières contre les incendies de forêts.

11. La réunion a recommandé que les gouvernements entreprennent des actions nécessaires à la sensibilisation du public, des décideurs et spécialistes des problèmes liés à la dégradation des sols.

12. Une attention particulière doit être accordée à l'éducation et la formation des spécialistes en protection et conservation des sols et eaux. A ce propos, la réunion a recommandé que soient: (a) organisés des cours spéciaux pour les étudiants et les écoliers; (b) accordées des bourses aux étudiants de la région; (c) organisés des visites et échanges d'experts entre les pays méditerranéens; (d) organisés des groupes de travail d'experts en vue de discuter et d'échanger les expériences relatives à la dégradation et la protection des sols; et (e) organisés des cours de formation consacrés à des thèmes tels que l'érosion hydrique et éolienne, la salinité et l'acidité des sols, la consolidation des dunes côtières, les pratiques de conservation, la gestion des forêts, etc.

II. DOCUMENTS PRESENTED AT THE SEMINAR
(SPLIT, APRIL 1987)

II. DOCUMENTS PRESENTES LORS DU SEMINAIRE
(SPLIT, 1987)

SYNTHESIS REPORT OF THE CASE STUDIES ON SOIL EROSION PROBLEMS

by

M. CIRIC
Faculty of Forestry
Sarajevo, Yugoslavia

1. OBJECTIVES OF THE SEMINAR

The Seminar was organised in accordance with the recommendation of the Meeting of Experts which took place in 1985 in Split, and its objectives were the following:

- to familiarise experts in the field and official representatives of individual countries with the objectives, programme and methods of PAP/RAC activity;

- to consider the completed Synthesis of National Reports, with incorporated summaries on the state of soil degradation in Turkey, Morocco, Libya, Malta and Algeria;

- to confirm the conclusions of the Meeting of Experts on soil degradation in Mediterranean coastal zones and on the most acute problems, as well as to confirm the choice of priorities for further actions of PAP/RAC;

- to consider the case studies, which summed up the deepened knowledge and experience of individual Mediterranean countries in the research of some essential aspects of rainfall erosion and the implementation of their results in the practice, and to make appropriate conclusions and recommendations for further co-ordinated activity;

- to consider the framework proposal of the co-operative project entitled "Inventory and Network of Soil Erosion Measurement in the Mediterranean for Environmentally Sound Land Management", the draft of which was made by PAP/RAC, FAO and ACSAD, and to define the basis for further elaboration of the project document;

- to consider the case studies on the measures for the protection of agricultural lands from non-agricultural uses in two typical Mediterranean situations which would be offered as the models to interested Mediterranean countries;

- to define the programme of further co-ordinated activities, taking account of the knowledge gained from the consideration of national reports, case studies, and observations of the expert missions.

2. PRESENTATION OF THE CASE STUDIES

After rainfall erosion was identified as the most acute form of soil degradation, common to all Mediterranean countries, the next step was a deeper analysis of Mediterranean research and practice, and some important aspects

of the problem were considered. Several proposals were discussed, and the choice between the available studies made according to the following criteria:

- financial and organisational capabilities limited the choice to 4 case studies;

- the studies chosen should make an organic entirety in their consideration of the problems of a possible inventory of erosion phenomena, experimental studies of erosion mechanisms under the Mediterranean conditions, integral measures of soil protection, and the importance of forest management for erosion control.

The following case studies were received within the specified term.

1. The making and use of soil erosion maps in the Mediterranean coastal zones in Turkey.

2. The Israeli concept for runoff and erosion control in semi-arid and arid zones in the Mediterranean basin.

3. An integral approach to catchment management in Italy.

4. Impact of the management of forests on the protection of soils and the environment in Morocco.

A short description of the case studies and a survey of the most essential conclusions which might be of interest for the majority of Mediterranean countries are presented below.

2.1 The making and use of soil erosion maps in the Mediterranean coastal zones in Turkey

Authors: M.Y. Kilinc
Civil Engineering Department, Middle East Technical University, Ankara

T. Celikkol
Erosion Control and Range Management Division, General Directorate of Forestry, Ankara

In presenting the situation on soil erosion in Turkey, the authors emphasise that rainfall erosion represents the most pronounced type of erosion in both intensity and occurrence in their Mediterranean coastal zone. About 75% of lands in the coastal zone of Turkey are exposed to strong erosion. The annual loss of soil because of erosion in Turkey amounts to 1800 t per mile^2 (in Europe 70 t), and is associated with enormous damage due to deposition of erosion sediments in the irrigation system and water storage basins. Mediterranean rivers carry 13.000.000 t of sediment annually. The sediments endanger harbours and form new river deltas, so that some coastal towns have been shifted away from the sea as far as 10 km (old Milet, for example).

The intensity of current erosion is in correlation with the devastation of forests and inadequate land use (inadequate machine cultivation, overgrazing, exploitation of steep slopes for agricultural crops). Erosion is also stimulated by frequent forest fires. Erosivity of rain, specific susceptibility of geological substrate and soil, as well as a high percentage of steep slopes (36%) are the factors causing high susceptibility of soils to erosion.

Such dramatic consequences of erosion have caused the competent authorities of Turkey to undertake extensive and long-term measures for the protection of agricultural and forest lands, as well as to provide for their optimum utilisation.

The basis for the planning of soil erosion protective actions is given in the pedologic map, elaborated (1965-1971) on the topographic base 1:25.000, and published on the scale 1:100.000 for the provinces, and 1:200.000 for the catchment areas. The following land properties were recorded during the survey: genetic soil groups, soil depth and inclination, stone contents, humidity, drainage rate, salinisation and sodification, alluvial and colluvial origin and textures of soil on slopes. Each of the properties has been separated in the map, and corresponding cartographic units have been separated thereafter.

Three main physiographic units have been differentiated: bottomlands, footslopes and uplands, and 20 large land groups are differentiated within them. The land groups are further differentiated by slope inclination, depth, stone contents and erosion degree. Classification criteria are then given in the form of a code containing all these properties. An example of a cartographic unit represents the unit coded B 7 t, 2, denoting:

- B = Brown soil (great soil group)
- 7 = moderately inclined shallow soils
- t = denotes stone contents
- 2 = denotes erosion degree - moderate erosion

The map of soil erosion was derived by interpreting the pedologic map 1:100.000. The map presents 4 degrees of erosion as based upon the standards adopted from the Manual of American Soil Conservation Service.

After the cartographic units have been separated according to erosion degree, the resulting areas of the units were so large that the map scale could be reduced to 1:1.000.000 and its reliability would remain preserved up to a level of 90%. However, the reliability of the pedologic map, from which the latter map was derived, was about 70%, so that the erosion map had an estimated reliability at the level of 60-65%. The erosion map has consequently been published in its final version on the scale 1:1.000.000. The reduction of scale has resulted in a compression in the number of cartographic land units, and the reduced map has been checked against the original topographic map of the same scale. The quality of the map in this respect would have been much higher had remote sensing images been used.

In their critical evaluation of the erosion map the authors have emphasised that more details could have been used and thus the separation of sub-units within the erosion degrees, according to land use, slope, type of limitation, etc. would have been possible.

The map is well suited for overall planning; for detailed planning and designing a map with greater detail is required (1:10-25.000).

One of the shortcomings of this project lies in the negligence in respect of forest lands which, in Turkey, are exposed to an extraordinarily high pressure, resulting in an augmentation of erosion areas.

The appearance of the map has had a remarkable influence upon public awareness, and made the public realise that Turkey had a serious erosion problem, especially for its coastal zone. Many governmental institutions and national agencies became aware of the need for urgent and integrated action.

The pedologic map and the map of soil erosion were used in the elaboration of the General Soil Management Plan of Turkey. One of the main tasks of the Plan is the fight against erosion and environmental protection with rational use of land resources. According to the Plan, the lands of Turkey have been divided into 79 management units, with land use and erosion protection methods defined for each unit. The plan completion has been scheduled for 50 years, with an annual rate of 721.000 ha and an expenditure of 266,4 billion T.L. The plan covers new soil research as an inevitable basis for the realisation of such an ambitious programme. A good deal of new knowledge, numerous new experts and a reorganised network of existing facilities in combination with modern technical methods will be required in addition to the existing expertise.

The soil erosion map of Turkey has verified the need for an inventory of erosion phenomena as a prerequisite for the establishment of a scientifically-based national programme of soil protection. The authors push forward the need for standardisation of such cartographic bases in the case of international co-operation, transfer of knowledge, and exchange of experience. They have suggested a comparative survey of existing maps and stimulation of Mediterranean countries to use the achieved Mediterranean experiences aiming at a harmonisation of the work methods. Such an action could lead to a standardised map of the Mediterranean coastal zones, which could represent the basis of a unique strategy in the fight against erosion. The authors consider this as a potential subject for a joint project, and their proposal is exposed in 12 items. The need for common efforts in employing aerial photography and remote sensing images to a higher degree has been specifically emphasised. Computer programmes for elaboration and interpretation of completed maps are also a necessary part of the project.

2.2 The Israeli concept for runoff and erosion control in semi-arid zones in the Mediterranean basin

Authors: M. Agasi, Y. Benyamini, J. Morin, and S. Marish
Soil Erosion Research Station, Rupin Institute Post, Emek-Hefer 60960, Israel

E. Henkin
Head of the Division of Soil Conservation and Drainage, Ministry of Agriculture, Hakiria, Tel-Aviv 61070, Israel

The study represents a synthetic presentation of experimental researches of erosion processes in different parts of Israel over the past 20 years. Long-term research has shown that the Universal Soil Loss Equation (USLE) is not applicable to Israel, neither was an integration of the delivery ratio into their models possible. In the Israeli approach to the problem of rainfall erosion, emphasis has been given to the study of the relationship between rainfall and physical and chemical properties of individual soils with an application of laboratory and field research methods.

The source of rainfall data is taken from the network of meteorological stations having the density of 1 non-recording station on 15 km^2 (in excess of 700), and 1 recording station on 150 km^2 (about 80), with an observation period of 30-50 years.

Rainstorms (the quantity of rainfalls in the period of time in which the intervals between rainfall segment do not exceed 24 hours) have been taken as the basis for the analysis of rainfall characteristics. Because the forecast methods are based on past meteorological data, any probability analysis is unreliable, so the authors applied several different methods in parallel. The rainstorm analysis defines the quantity, intensity and kinetic energy of the rainfall. Best correlation versus runoff was observed with kinetic energy expressed as R in USLE equation.

The runoff of a given rainstorm is the function of the soil infiltration rate, surface storage capacity and rainfall intensity distribution and sequence. The surface crust (1 mm) which is formed in many semi-arid regions as the result of direct impact of raindrops and dispersing effect of exchangeable Na^+ ion represents the main factor in controlling the infiltration rate. A minimum percentage of exchangeable Na - ESP 1-2% causes clay peptisation and the formation of a surface crust, resulting in a remarkable reduction of the infiltration rate. A mathematical forecast model has been developed to study the infiltration rate by combining the infiltration equation with rainstorm analysis and surface accumulation and detention factor (SD). A comparison between the runoff prediction model and actual measurements showed a high correlation. The model can be applied for runoff forecasts in smaller basins (2-3 ha).

Extensive experiments have been performed by means of rain simulators under laboratory conditions (boxes 30 x 50 x 10 cm) and small yield plots (1,5 m^2), as well as on plots exposed to natural rainfall (5 x 20 m and 9 x 100 m). This method was employed to study the consequences of agrotechnical measures upon runoff and soil erosion. The studies comprising the influence of 10 different types of cultivation upon the rate of infiltration showed that the highest rate was observed with operations creating aggregates of larger size. The results were verified on field plots (25 x 6 m) with added dyked-furrow treatment which improved the detention and remarkably reduced runoff. All the experiments show that the types of cultivation which increase the rate of infiltration, surface storage and detention (SD), have a rainfall reduction of 60-70% with respect to the control.

The dispersing influence of exchangeable sodium has been prevented by application of phosphorus-gypsum (a side product in the industry of phosphorus fertilisers) in various alternatives. By spreading 5 t of PG over land surface, runoff is reduced by 75%, resulting in an increase in infiltration rate of 2 mm/h on the control sample to 10 mm/h on the treated plot. This measure has proved to be very effective as almost 80% of rainstorms in Israel have an intensity of less than 8 mm/h. The positive effect of PG is kept until it is in the concentration permitting clay flocculation.

The climatic conditions under which the experiments were performed are typical Mediterranean: 400-800 mm of rainfall distributed during the winter months. The types of soils in the experiments represented the group of most important agricultural lands of Israel (calcic luvisol, vertic luvisol, chromic luvisol, chromic vertisol). After having analysed the natural

conditions of the Mediterranean, the authors concluded that these results would be applicable to the southwestern ring of the Mediterranean, Levant, Mediterranean coastal zone of Turkey, Cyprus and Crete, southern Greece and southern Italy, Sicily and Sardinia, and Spain.

In order to ensure the successful co-operation recommended by the authors, they have prepared the formation of a Working Group with the following remit:

- to develop the principles of problem definition and standardisation of methods, to organise the data collection from measuring plots and their common processing;
- to establish two or three research centres to study the relationships between rainfall and runoff using rain simulators, for all Mediterranean countries;
- to standardise the methods for collection and processing of meteorological data;
- to standardise soil classification;
- to organise courses for training of personnel and consultation meetings of experts.

2.3 An integral approach to catchment management in Italy

Authors: F. Mancini and S. Graci
Istituto Sperimentale per lo Studio de la Difesa del Suolo, Firenze, Italy

Within the Italian coastal zone, four-fifths of the territory is subject to erosion. The degree of erosion occurrences corresponds with the migration of population. The mountainous regions, populated as early as the pre-historic period, were exposed to deforestation, overgrazing and inadequate use of agricultural land until the second half of this century. The consequences were reflected in the high frequency of catastrophic floods and the settlement of enormous deposits of sediment. Historical records state that the basin of the Arno river was hit by 6-7 floods during the whole of the 16th century. The frequency of floods increased, and there were as many 20 floods in the 18th century.

The fight against erosion has a long tradition in Italy, and in recent decades the concept of integral catchment management has been developed and consolidated. The implementation of these measures was entrusted to the united regional service "Communita Montana", and the projects were realised by an interdisciplinary team of experts in which engineers, geologists, pedologists, foresters, agronomists and economists participated. The successful realisation of this activity is promoted by adequate legislation.

To demonstrate the experiences on the implementation of such an approach to the problem of soil protection, the authors selected the Staggia stream catchment (47,6 km^2), the tributary of the Arno river (Arezzo province in Toscana). The catchment is typical for Appenines, consisting of sandstones and siltstones, with some marly limestones and clay schists. The main soil type is distric cambisol of various textures. The vegetation in the upper

catchment zone consists of beech, lime trees, elm and fir, whereas oak (Pubescens cerris) is prevalent in the downstream belt. The mean annual temperature is 12-13 °C in the valleys, and 7-8 °C on the mountains. The total amount of precipitations is 1300-1800 mm, and the curve of their intensity explains the high frequency of flood. The catastrophic floods in the years 1926 to 1927 caused extensive and radical measures to be undertaken in the catchment.

Forest works comprised the conversion of low forests and afforestation including terrain consolidation. The area under forest has thus increased from 55% (in 1930) to 89%. Such an increase of forest lands was possible due to the abandonment of agricultural land and the migration of population to industrial areas. In mountainous regions, only fragments of agricultural lands and grasslands have been retained which have the capacity to maintain wildlife.

Afforestation was performed by special erosion control technique; the following tree species were planted: silver fir, Corsican pine and Pseudotschuga duglasii, together with beech, chestnut and oak.

Hydrologic works comprised the construction of 59 barrages in all the tributaries of the micro-basin in order to prevent stream bed cutting, to consolidate the slopes, as well as to stop bed cutting, to consolidate the slopes, as well as to stop the sediment transport by reducing the flow velocity. Other technical works have also been performed in the stream bed.

The positive effects of these works are very convincing. The slopes are completely consolidated under dense forest, the hydrographic network has been consolidated, and the average annual figure of transported sediments has dropped from 565 t/km^2 to 360 t/km^2. The authors emphasised the need for maintenance of all these structures in order to keep the measures effective.

2.4 Influence of forest management upon soil and environmental protection in Morocco

Authors: M. Azeba and F.A. Filali
Provincial Directorate of Agriculture, Al Hoceima, Morocco

The devastation of forest cover and the degradation of the ecosystem which started in colonial times, continued up to the present, mainly due to a high population pressure. High requirements for wood, forest fires and uncontrolled grazing have resulted in increased soil erosion with the following negative consequences:

- the loss of fertile lands;
- changes in infrastructure (filling of storage basins, damage to roads, increased frequency of floods, disturbance of groundwater regime, damage of irrigation network, filling of harbours, degradation of scenery, regression of fauna).

In the reclamation of catchment basins, integral catchment management has been emphasised, and the socio-economic factor has a central position. An example of the realisation of such a concept given in the Study, is the reclamation of the catchment area Neckor (78.000 ha), part of the eastern part of the mountain ridge Rif. The area is characterised by predominant

shist-marble substrate, and its altitude ranges from 120 m (at the dam site) to 2000 m in the mountainous backland. 40% of the slopes have an inclination over 50%, and slopes with an inclination below 20% make up 18% of the area. The soils are poorly developed and shallow, except a few terraces where deeper soils have been preserved. The climate is Mediterranean with rainfalls varying from 300 mm in valleys to 1000 in the mountainous part. In bioclimatic belt Oleo-lentiscus, the lower drier part is occupied by xerothermal vegetation dominated by arbovitae, while in higher parts Quercus ilex predominates. All these conditions cause the Neckor area to be exposed to excessive erosion (3.500 t/km^2/year).

In the planning methodology of catchment area management, one has to start from land classification, taking into account the relief, the physical and chemical properties of soil, the condition of the vegetation, the aggressiveness of climate, and the degree of active and potential soil erosion. An essential criterion in the classification of a catchment area is the change of phyto-ecologic conditions, because biological measures, especially afforestation, represent the most important activity within the reclamation measures. Mechanical measures are largely utilised in the successful afforestation of erodible terrains, and to provide the ecosystem with direct protection, within a short period, from the harmful consequences of erosion. Traditional arboriculture is being stimulated by granting fruit seedlings to the farmers in order to make them join the project, though the erosion control function of these cultures is inferior when compared with forest trees. That is a necessary compromise, the consequences of which are mitigated by the construction of terraces and other erosion control structures. While arboriculture is based on well-drained terrains, growing vineyards and green cattle food is recommended for heavier lands. Grasslands are arranged in the form of belts, a widespread form of biological protection. Some afforestated terrains within the coastal zone are of wider ecologic importance, including the restoration of bird populations. The efficiency of the measures undertaken depends on the co-operation of the local population, and their interests are determined by carrying out polls.

The area of Neckor has been declared the catchment area of national interest, because the results achieved in it have to serve as a model for similar catchment areas throughout Morocco. The works in this area were initiated back in 1950, and during the completion of the project Derro (initiated in 1963), the following steps were undertaken:

(a) the areas under forest have been enlarged from 2% to 12%. Trees were selected from species already grown in existing cultures taking account of their protective and productive function. The protective function has been confirmed, and the productive function has still to be evaluated. Within the afforestation technique, the preparation of lands and the accompanying engineering works have made for the success of afforestation;

(b) the main species in arboriculture are the almond, olive, fig, pear, apple and plum. Various protective measures have been employed in this culture, depending on topography and substrate (hedges at plot boundaries, stone walls, microbasins for water retention, etc.);

(c) the reclamation of grasslands has centred on the establishment of permanent grass areas, laying grass belts, planting trees, replacement of fallows by plants for cattle food;

(d) the mechanical works have consistently aimed at the control of erosion deposit movement in order to achieve the protection of environment within a short period, and these were supported by various types of barriers. These measures proved ineffective unless reinforced by biological measures;

(e) the construction of 180 km of roads, schools, health centres, and other structures, as well as a remarkable input of capital have contributed to economic progress and an increase in employment.

In summing up their experience, the authors specifically underlined the need for an integral management of the upstream and downstream parts of the area, so that the planning should include the hinterland of the coastal zone.

3. SYNTHETIC REVIEW OF THE CASE STUDIES

The rainfall-induced soil erosion in the coastal zones of the majority of Mediterranean countries has reached such a scale that it goes beyond mere local concern, and requires intervention at national level. This problem ought to become the subject of attention of wide social communities considering that it is associated not only with an irreversible loss of soil as an unrenewable natural resource on a large scale, but also with the consequences of erosion which have an adverse effect upon water resources and irrigation systems, roads, settlements and harbours, with an impact upon socio-economic relationships within wider regions.

The national programmes of soil protection against erosion are to be based on factual information concerning the occurrence, form and intensity of erosion. The inventory of forms and intensity of rainfall erosion, as well as of erosion risks in the form of erosion maps, represents the first level of information required for the elaboration of soil protection plans at national or regional level.

Two types of erosion maps can be distinguished: the first is a statistical presentation of the condition at the time of the survey, which presents the form of erosion and the degree of its occurrence, as estimated on the basis of visible consequences, i.e. according to the magnitude of soil loss with respect to normal conditions; in the other type, which could be called "dynamic", the possible degree to erosion is estimated under specific conditions, i.e. soil erodibility or erosion risk.

For the Seminar, the experience of Turkey in the elaboration and use of the erosion map of the first type is presented. The map has been obtained as an additional product of the elaboration of the pedological map, considering that the programme of the survey also included the identification of form and degree of soil erosion for each cartographic unit. From the interpretation of such a map, it was possible to derive the map of erosion on the same and on a reduced scale. However, the usefulness of such a map is limited, as was confirmed by the Turkish experience. By presenting the frequency of the occurrence of the phenomenon and the size of the damage, it can arouse public interest in the issue and stimulate corresponding institutions to consider the problem of erosion in their national and regional planning and properly allocate appropriate means to combat the erosion. The elaboration of such a map can therefore be justified only if it is an additional product to a pedological map, or if it is made through application of modern technical

means (remote sensing techniques) in a short period of time. The scale taken for the map in Turkey (1:1.000.000) seems to be adequate for the purpose.

By far the most valuable is a map of potential erosion separating the cartographic units according to the degree of soil erodibility and expressed as a quantity of soil mass (in t/ha) eroded in a year. Such a map offers a better basis for the elaboration of preventive measures in the sense of proper selection of land use and type of cultivation, as well as for the design of erosion control technical measures. Such type of map has been completed for North Africa and the Near East by FAO, UNEP and UNESCO on the scale 1:5.000.000. According to information in the national reports, such maps are available in Tunisia and Libya.

In view of the existing situation, the proposal made in the review of the Turkish Case Study, to make the erosion map of the whole Mediterranean coastal zone apply a uniform methodology, seems very appropriate. Such a basis could provide for a very effective and reliable transfer of knowledge and experiences obtained in this region. It is obvious that the possibilities offered by modern interpretation of the remote sensing technique should be applied.

The elaboration of such map assumes the availability of prediction models, the function of which should be confirmed under specific Mediterranean conditions. The evaluation of erosion risks is most commonly performed today by means of Universal Soil Loss Equation (USLE), which is also taken as the basis of FAO method (Guidelines for Soil Degradation Assessment, 1979). However, the experience in the majority of Mediterranean countries shows that this model is not applicable under Mediterranean coastal zone conditions. That has been explicitly confirmed in numerous experiments performed in Israel. In addition to its unsuitability for Mediterranean conditions, this method assumes a level of research and data not available in the developing countries. For the case of gully erosion, no generally-accepted method exists at all. Hence, the development of a simpler and more suitable method for the evaluation of soil erodibility presents a task of current concern for the Mediterranean countries.

The development of the prediction model and the programming of erosion control measures requires the best possible knowledge on both the mechanism of erosion processes and the factors causing them. Research of that type has been performed in Israel, especially in the last decade, and quite important results of the research have been presented as the Case Study in this Seminar. The experience gained in this research shows:

- that the subject of research has to be clearly defined;
- that the methodology of research has to combine the laboratory research with experiments under field conditions on small plots by means of rain simulators, and on Wishmayer plots under natural rainfall;
- that the rainstorm probability analysis requires the application of several models, because the reliability of single models is rather low;
- that the results of such research are widely applicable, provided the conditions of the experiment have been correctly defined.

The research results obtained are at a high scientific level and, having a wider importance for the Mediterranean, can be used in the fight against erosion in the semi-arid regions of the Mediterranean.

The prediction models deserve special attention considering that they have been tested under Mediterranean conditions, and were based upon the relationship between rainfall energy and soil properties, thus the method is made simpler and the amount of data required is reduced to the basic parameters only. These models can therefore be accessible for a large number of countries. More extensive testing of these models in Mediterranean coastal zones could result in a uniform approach to the problem and the faster availability of adequate models.

Some of the information from the Israeli experiments could be directly introduced into the practice of all semi-arid zones of the Mediterranean. In the first place comes the application of phosphorus-gypsum on all soils which have an increased content of the exchangeable Na^+ ion, and are susceptible to erosion. Agrotechnical measures providing for coarse structural aggregates could also be put directly into operation. It would be a great impetus for general Mediterranean action if this methodology and these types of experiments could be included in the research programmes of corresponding Mediterranean countries and then be co-ordinated. This would result in a remarkable promotion in the level of experimental work and an early availability of the information required to fight erosion effectively.

An integral approach to catchment management has proved to be the most effective method of erosion prevention and environmental protection. The catchment is to be understood as a dynamic integral socio-economic and physical system comprising people, agriculture, industry, communications and recreational facilities. Each of these activities can disturb the balance of the system. So, for example, logging and road construction can result in the removal of trees and vegetation and, consequently, in increased runoff, causing erosion which influences the water supply and causes water pollution. The essence of the integral approach to catchment management lies in the co-ordinated use and management of land, water, vegetation and other physical resources and activities within the catchment in order to reduce soil degradation and erosion to a minimum, with minimal negative impact upon the quality of the environment. This approach is today of general concern in the world, and the efforts of the Mediterranean countries to implement it are welcome.

In the case of Mediterranean coastal zones, it is necessary to point out that various types of drainage basins and various models of integral management are present in this area. In Italy, for example, the majority of basins have the following characteristics:

- abandonment of agricultural lands due to the migration of population into industry, and conversion of such terrains into forest lands;

- agriculture carried out only on fertile lands in plains along river valleys where erosion is of no concern;

- afforestation performed on the basis of previous research and various cartographic bases, as well as other technical documentation;

- the process of afforestation having been initiated several decades ago, many basins contain terrains with different stages of reafforestation, so that evaluation of results is possible;

- afforestation accompanied by mechanical works within the catchment aimed at the stabilisation of terrains and hydrological network.

Drainage basins in the countries of North Africa have more or less the following characteristics:

- multipurpose land use present within the same basin, so that diverse interests have to be brought into accordance;

- erosion present in various forms and intensities, so that different protective measures have to be applied;

- high population pressure still reflected in the claims for forest terrains resulting in new focal points of erosion;

- choice of forest tree species for afforestation restricted because of unfavourable environmental conditions;

- the need for water resources management and construction of water storage for irrigation;

- an emphasis on the necessity of protecting all environmental resources, because the loss of soil causes the sedimentation in water courses and basins, endangers the harbours, settlements and communications with serious socio-economic consequences;

- work on catchment management scarcely begun, and the degree of integration of all activities not sufficiently expressed.

In view of the diversity with respect to natural and economic conditions and differing experience, a synthetic study on this activity and the organisation of training courses on the sites representing the typical models of Mediterranean drainage basins would be desirable.

4. PREPARATION OF THE CO-OPERATIVE PROJECT

The draft of the Co-operative Project under the name "Monitoring and Assessment of Rainfall-induced Erosion in Mediterranean Coastal Zones" has been prepared in co-operation with FAO according to the recommendations of the Meeting of Experts and finally formulated in the meeting in ACSAD as the proposal of PAP/RAC, FAO, ACSAD.

The draft of the project frame proposal originates from the following facts:

- rainfall erosion is the most common and the most important form of soil degradation in Mediterranean coastal zones. Though the general knowledge of erosion phenomena is rich, an understanding of specific Mediterranean features associated with these phenomena is insufficient and incomplete data have been collected under different methodological approaches which often makes them incompatible;

- in order to improve the required specific knowledge, it is necessary to intensify the measurements of relevant parameters on erosion processes, to harmonise the methods and to co-ordinate the activities. These are necessary conditions for a further co-operation in the design and construction of erosion protection measures and training of personnel.

The long-term objective of the Project lies in its contribution to the promotion of soil protection in Mediterranean coastal zones against rainfall erosion.

The direct objectives of the Project are:

- to prepare an inventory of the conditions relating to soil erosion and its control in Mediterranean coastal regions;

- to create a common methodology and programme for monitoring the relevant erosion phenomena on runoff plots;

- to create a Mediterranean network of monitoring procedures and installations and experts in the field;

- to establish the relevant information system as the basis for data processing;

- to perform the training of local experts engaged in this activity;

- to elaborate the synthetic report and formulate the conclusions and recommendations and the proposal for further actions.

It is expected that the results of the Project will be used by:

- institutions and experts engaged in the soil protection in the Mediterranean, for the better understanding of erosion phenomena in the region;

- institutions and experts engaged in the planning and design and in the construction of erosion protective measures for an improvement in the efficiency of their work;

- decision-making authorities as the basis in the planning of further activities.

Missions of experts have so far taken part in Syria, Italy, Tunisia and Algeria. The information collected on the missions have revealed that:

- in all countries in which the mission took part, a global support had been given to the project proposal and the action had been evaluated as very useful both for individual countries and the entire Mediterranean region;

- it has been confirmed that rainfall erosion is widespread in coastal zones, especially on marls and other loose sediments, and it is associated with obvious adverse consequences for all environmental systems;

- because of the strategy of economic development in individual countries, the main accent in the research into erosion and the measures to combat it has been put on continental regions which are beyond the borders of coastal zones in the sense of our definition;

  considering that these regions are under the influence of the Mediterranean climate as well, the relating experience obtained so far can be taken into account, but the monitoring stations located in these regions cannot be included in the planned network. The knowledge that some countries (Syria, for example) do not have a developed soil protection service, brings one to the conclusion that the intensity of research and implementation of soil protection measures in coastal zones of the Mediterranean do not suffice, in the face of the extent of soil endangerment;

- in the strategy of fighting erosion, the need to prevent erosion at its very origin, i.e. by selecting the appropriate land uses and by growing adequate agricultural crops, has not been given enough emphasis. The main efforts in future experiments should, therefore, be concentrated upon research of the agrotechnical systems providing the best protection of soils from erosion;

- though the idea of integral catchment management already exists, the implementation of such an approach is, in practice, very often kept at a low scale of integration of all the technical, ecologic, socio-economic elements of that activity. The promotion of an integral approach to the management of a catchment area as a planning unit and the training of personnel for such work is a current need in Mediterranean coastal zones;

- though the majority of countries have adequate organisation of soil protection services and a certain number of adequately trained personnel, there is a need to send experts to assist in specific work, such as the construction of monitoring stations and the implementation of the soil protective methods by influencing the structure and method of agricultural production;

- in view of the inadequately develcped network of experimental plots in coastal zones, the original concept of introducing co-ordination between existing monitoring stations has had to be altered, and the stress is to be put on the establishment of a network of monitoring stations. This has certain advantages which can be expected in an easier establishment of a unique methodology and achievement of complementarity of the network;

- in order to obtain an adequate distribution of the monitoring stations, it would be necessary to make an inventory of occurrences and forms of erosion phenomena in the Mediterranean coastal zone, employing the remote sensing technique;

- according to established conditions, it is obvious that the main concern of the monitoring stations should be concentrated on the influence of agricultural crops and agrotechnical systems upon the erosion and sediment yield, in order to determine the most effective erosion protective agrotechnical systems;

- the erosion in semi-arid regions, with low frequency of erosive rainfalls, is of specific interest. Therefore, in addition to the measurement of erosion effects on the runoff plots, the experiments with rain simulator on the same plots and variables can offer valuable complementary data;

- in UNEP's approach to the problem of erosion, it is important to monitor erosion sediment movement and to measure sediment discharge from the catchment area in gauge stations. This would represent an essential component of measurements within the network;

- though aware of the importance of and need for the proposed action, the experts and authorities of individual countries emphasised that without financial support from outside, the prospects for the success of such action are not favourable.

5. CONCLUSIONS

On the basis of completed activities and the case studies considered in this paper, the following conclusions can be proposed.

5.1 It has been confirmed that rainfall erosion presents the most serious form of soil erosion with consequences that endanger the entire environmental and socio-economic system of the Mediterranean coastal zones. This problem should, therefore, be placed in the centre of activities within the priority action "Promotion of soil protection as an essential component of environmental protection in Mediterranean coastal zones".

5.2 From the aspect of the coastal environment, both arable agricultural lands and forest lands are of equal significance.

5.3 The existing knowledge on the research status of erosion processes in Mediterranean coastal zones shows that:

- some general aspects of information on water erosion are not applicable under specific Mediterranean conditions;

- coastal zones have not been covered by adequate research to the degree of present erosion due to differing development levels of protection services, or differing national priorities;

- the level of research and measurement of erosion relating parameters which are the basis for fighting erosion is not uniform, and depends on the general development of the country, and on its policy with respect to soil resource uses and traditions.

5.4 Experts in the field and in relevant governmental institutions show a great interest in co-operation among the Mediterranean countries, and believe that, in spite of local differences, such co-operation can be of great use for

all participants. All adopted forms of co-operation are of interest: exchange of information, joint seminars and workshops, joint projects, training courses, expert missions and technical assistance in equipment.

5.5 The inventory of occurrence, form, and intensity of erosion through elaboration of erosion maps is an inevitable assumption for the successful establishment of any form of co-operation. Such inventories have been completed in several Mediterranean countries but with different methods and at differing professional levels. The facilities offered by modern remote sensing techniques have not been used so far in the elaboration of erosion maps, though they permit the elaboration of satisfactory accurate and uniform maps for all Mediterranean coastal zones in a short period of time.

5.6 The development of erosion risk prediction models and the collection of data required in the planning of erosion protective measures, require intensive experimenting over a longer period of time. The associated research has been developed in certain Mediterranean countries, and the relevant results are applicable to broader parts of the coastal zones.

5.7 The belief in the necessity of an integral approach to catchment management in the planning and construction of erosion protection measures exists but, in reality, the degree of implementation of that concept often differs. The obstacles to a consequent implementation of that concept can be:

- insufficient knowledge of the concept and methods for integration of individual activities;

- a background of traditional experience associated with an impact of work segments (agriculture, forestry, engineering);

- difficulties resulting from the refusal of local inhabitants to accept deeper changes in the ways of land use and farming;

- deficiencies in the requisite experience in the planning of such activities.

5.8 Afforestation has proved to be a very effective measure in erosion prevention and reclamation of seriously disturbed ecosystems. The problems of tree species, specific afforestation techniques of erosive terrains, and classifications of land uses which are to confirm the justification of afforestation are to receive central attention.

5.9 In the consideration of integral catchment management approaches in Mediterranean coastal zones, varying types of catchments can be encountered involving different types of solutions. An identification of such types and the summing up of experiences for each type would result in a remarkable promotion of integral catchment management level.

5.10 There is a need for technical assistance in the developing Mediterranean countries in the form of technical equipment (pluviographs, limnigraphs, rain simulators), or delegations of expert missions to assist in solving specific problems, as well as in the organisation of training courses in most advanced centres within the Mediterranean countries.

6. RECOMMENDATIONS

6.1 The problems associated with rainfall-induced soil erosion are to remain in the centre of activities within the Priority Actions Programmes on soil protection for the next period, using all introduced forms of co-operation.

6.2 In order to encompass all the erosion relating factors, PAP/RAC should consider the possibility of including the aspects of forest fires in the wider context of soil protection activities.

6.3 The specific activity is to be concentrated on the elaboration and implementation of the co-operative project entitled "Inventory and Network of Soil Erosion Measurement in the Mediterranean for Environmentally Sound Land Management". So formulated, and yet representing an integral entirety, the project incorporates three important problems of rainfall erosion: (i) the elaboration of thematic erosion maps as background in the planning of future actions and effective exchange of experience; (ii) the establishment of a matched and co-ordinated network of measuring stations to provide the reliable data that are required in modern soil protection; (iii) direction of all relevant activities towards the development of an integral catchment management system as the most effective method for an optimum environmental protection within coastal zones.

6.4 Individual segments of this integral project can be realised as independent actions to the extent that the financial means are provided for. It is, accordingly, recommended that PAP/RAC undertakes the following actions in the next period:

- to organise expert missions associated with the project or upon demand of individual countries when such demands fit the overall concept of the project;

- to identify the most advanced centres for individual activities within the project and to explore the possibilities of their availability to all the participants for specific research services and training facilities;

- to define current needs in equipment and to estimate the possibility of providing such equipment as technical assistance to the developing countries;

- to find adequate means of stimulating the introduction of modern surveying and measuring methods which are to improve the quality and productivity of the activities associated with the project;

- to employ adequate communication means for popularisation of the concept of integral catchment management as the method which offers optimum environmental system protection;

- to organise workshops which are to support a successful preparation and implementation of the project.

SYNTHESE DES ETUDES SUR LES PROBLEMES D'EROSION DU SOL

par

M. CIRIC
Faculté forestière, Sarajevo, Yougoslavie

1. OBJECTIFS DU COLLOQUE

Sur la base des recommandations de la réunion d'experts, tenue à Split en 1985, ce colloque a été organisé avec les objectifs suivants:

- informer un cercle d'experts et de représentants officiels des pays participants sur les objectifs, le programme et les méthodes d'activités du CAR/PAP;

- examiner la synthèse des rapports complétée, avec les résumés incorporés sur la situation de la dégradation des sols en Turquie, au Maroc, à Malte et en Algérie, et confirmer les conclusions de la réunion d'experts sur la dégradation des sols dans les zones côtières méditerranéennes ainsi que les problèmes les plus actuels et le choix des priorités pour l'action future du CAR/PAP;

- examiner les études de cas, dans lesquelles sont regroupées les connaissances et les expériences de certains pays méditerranéens dans les recherches de certains aspects importants d'érosion par la pluie et dans l'application desdits résultats en pratique, et définir les conclusions et les recommandations pour l'activité de coordination future;

- analyser l'étude cadre du projet de coordination sous le titre "Inventory and Network of Soil Erosion measurement in the Mediterranean for Environmentally Sound Land Management", dont le projet a été réalisé par CAR/PAP, FAO et ACSAD, et définir les bases pour une élaboration future du dossier;

- analyser les études de cas sur les mesures de protection des terres agricoles contre l'utilisation non-agricole et les présenter aux pays méditerranéens intéressés en tant que modèles de deux situations méditerranéennes différentes mais typiques;

- définir le programme d'activités de coordination futures, en tenant compte des connaissances acquises sur la base des rapports nationaux, des études de cas et observations des missions d'experts.

2. ANALYSE DES ETUDES DE CAS

Etant donné que l'érosion due à la pluie a été définie comme la forme la plus actuelle de la dégradation des sols, commune à tous les pays méditerranéens, la démarche suivante consiste en une analyse plus détaillée des recherches méditerranéennes et des expériences dans le but de mettre en évidence certains aspects importants de ce problème. Plusieurs propositions ont été examinées et un choix a été fait selon les critères suivants:

- les moyens financiers et organisationnels ont limité le choix à 4 études de cas;

- les études choisies constituent un ensemble organique, traitant les problèmes d'inventaire des phénomènes d'érosion, les recherches expérimentales des mécanismes d'érosion dans les conditions méditerranéennes, les mesures intégrées de protection des sols contre l'érosion et l'importance d'une exploitation rationnelle des forêts pour le contrôle de l'érosion;

Les études de cas suivantes sont parvenues dans le délai prévu:

1. The making and use of soil erosion maps in the Mediterranean coastal zones in Turkey.

2. The Israeli concept for runoff and erosion control in semi-arid and arid zones in the Mediterranean basin.

3. An integral approach to catchment management in Italy.

4. L'impact de l'aménagement des forêts sur la protection des sols et de l'environnement au Maroc.

Nous donnons ci-après un résumé sommaire des études de cas, ainsi que les conclusions importantes d'un intérêt commun pour la plupart des pays méditerranéens.

2.1. <u>The making and Use of Soil Erosion Maps in the Mediterranean Coastal Zones in Turkey</u>

Auteurs: M.Y. Killic
Civil Engineering Department, Middle East Technical University, Ankara

T. Celikkol
Erosion Control and Range Management Division, General Directorate of Forestry, Ankara

En présentant une analyse de l'érosion des sols en Turquie, les auteurs soulignent que l'érosion hydrique, par son intensité et par sa présence, est la plus marquée très précisément dans leur zone côtière méditerranéenne. A peu près 75% de la superficie de la zone côtière turque est exposée à une érosion forte. La perte annuelle des sols en Turquie s'élève à 1800 t. par lieue carrée (contre 70 t. en Europe) provoquant des dégâts importants dus au dépôt de sédiment érodé dans les systèmes d'irrigation et dans les accumulations d'eau. Les fleuves méditerranéens déposent dans la mer presque 13.000.000 tonnes de sédiment par an. Ces sédiments représentent un vrai danger pour les ports et les nouveaux deltas formés, et certaines villes côtières ont reculé de la côte de 10 km même (site ancien de Milet par exemple).

L'intensité d'érosion actuelle est en corrélation avec le degré de la dégradation des forêts et avec l'exploitation inadéquate des sols (mauvaise utilisation de la mécanisation, surpâturage, utilisation des terres en déclivité pour les cultures agricoles). L'érosion est également aggravée par les incendies de forêts fréquents. Le caractère érosif de la pluie, la sensibilité particulière du sous-sol géologique et du sol, ainsi qu'une participation élevée des pentes (36%) sont des facteurs qui conditionnent une forte sujétion du sol à l'érosion.

Ces conséquences dramatiques de l'érosion ont incité les institutions compétentes en Turquie à entreprendre des actions considérables à long terme dans le but de protéger les terres agricoles et forestières et d'assurer leur exploitation optimale.

La base de la planification de l'action de protection des sols contre l'érosion est une carte pédologique réalisée (1965-1971) sur une base topographique à l'échelle 1/25.000, établie à l'échelle 1/100.000 pour les provinces et en 1/200.000 pour les bassins versants. Lors des levés, on a enregistré les caractéristiques suivantes du sol: groupes génétiques du sol, profondeur et déclivité des terrains, caractère rocheux du terrain, humidité-drainage, salinisation et alcalisation, degré et type d'érosion, nature de la couverture et utilisation du sol, origine alluviale et coluviale et texture des terrains en déclivité. Chacune de ces caractéristiques est différenciée sur la carte, puis les unités cartographiques correspondantes ont été séparées.

On distingue trois unités physiographiques - plaines, pieds des collines et des montagnes - dans le cadre desquelles on peut isoler 20 grands groupes de sols. Ces groupes sont aussi divisés en fonction des pentes, de la profondeur, du caractère rocheux et du degré d'érosion. Pour toutes ces caractéristiques, on avait donné des critères de répartition suivant une clé particulière. Comme exemple d'unités cartographiques nous pouvons prendre, à titre d'information, l'unité marquée par B 7 t, 2, dont le code a la signification suivante:

- B = sols bruns (le plus grand groupe)
- 7 = sols peu profonds, légèrement inclinés
- t = indice du caractère rocheux
- 2 = indice du degré d'érosion - érosion moyenne.

Par l'interprétation de la carte pédologique au 1/100.000, on avait établi une carte d'érosion. La carte donne 4 degrés d'érosion en fonction des normes reprises des manuels du service américain de protection des sols (Soil Conservation Service).

Après la distinction des unités cartographiques selon le degré d'érosion, on a obtenu des superficies d'unités aussi importantes que l'échelle de la carte a pu être réduite à 1/1.000.000, tout en conservant la fiabilité de la carte jusqu'au niveau de 90%. Cependant, étant donné que la fiabilité de la carte pédologique ayant servi de base, n'est que de 70%, la carte d'érosion est fiable jusqu'au niveau de 60-65%. C'est la raison pour laquelle la carte d'érosion est établie, dans sa version définitive, à l'échelle 1:1.000.000. Lors de la réduction de l'échelle, une contraction du nombre d'unités cartographiques s'est produite, et la carte réduite est contrôlée à l'aide de la carte topographique initiale à l'échelle identique.

Dans une estimation critique de la carte d'érosion, les auteurs ont signalé que l'on aurait pu utiliser plus de détails lors de l'établissement de ladite carte. Ces détails auraient pu permettre de distinguer des sous-unités dans le cadre du degré d'érosion, sur la base de l'utilisation des sols, du type de contraintes, etc.

Cette carte est utilisable pour les prévisions générales, mais pas pour les planifications et études plus détaillées, auquel cas il sera nécessaire d'utiliser une carte plus détaillée (10-25.000).

L'un des défauts essentiels dudit projet est en fait que les terrains forestiers ont été négligés, bien que la pression sur ces terrains soit énorme en Turquie, ce qui a résulté en une extension des superficies érodées.

La publication de cette carte a contribué à ce que l'opinion publique comprenne le danger d'érosion pour la Turquie, surtout pour la zone côtière. Plusieurs institutions d'Etat et agences nationales sont devenues conscientes de la nécessité d'une action urgente et concertée.

La carte pédologique ainsi que la carte d'érosion des sols ont été utilisées pour l'établissement d'un plan général de gestion des terres en Turquie (Soil Management Plan). La principale tâche dudit plan consiste en une lutte contre l'érosion et en une protection de l'environnement moyennant une exploitation rationnelle des ressources terrestres. Sur la base de ce plan, les sols en Turquie sont divisés en 79 unités de gestion.

Pour chacune de ces unités, on a défini le mode d'utilisation du sol ainsi que la méthode de protection contre l'érosion. La réalisation du plan porte sur une période de 50 ans, soit 721.000 ha par an et une consommation de 266.4X 10^9 T.L. Dans le cadre dudit plan il sera effectué une nouvelle étude des sols, en tant que base indispensable à la réalisation d'un plan si ambitieux. Outre l'expérience acquise, il sera nécessaire d'assurer de nouvelles connaissances, un grand nombre de spécialistes et un réseau réorganisé des capacités existantes.

La carte d'érosion des sols en Turquie a démontré la nécessité d'établir un inventaire des phénomènes d'érosion, comme hypothèse pour l'instauration d'un programme de la protection nationale fondé sur des bases scientifiques. Les auteurs signalent qu'il serait indispensable d'unifier ces bases cartographiques pour une coopération internationale et pour un transfert de savoir et d'expérience. Les auteurs suggèrent de réaliser un tableau comparatif des cartes existantes ainsi que d'inciter des pays qui ne commencent qu'à traiter ces problèmes à utiliser les expériences méditerranéennes acquises, dans le but de normaliser la méthode de travail. Cette action pourra permettre l'établissement d'une carte standardisée des zones côtières méditerranéennes, en tant que base de stratégie commune de la lutte contre l'érosion. Les auteurs sont d'avis que ceci pourrait représenter le sujet d'un projet commun et exposent leur proposition en 12 points. Ils suggèrent plus particulièrement la nécessité d'introduire, par des efforts communs, l'utilisation des levés aériens et des levés par télédétection.

Les programmes informatiques seront également indispensables à l'établissement et à l'interprétation des cartes réalisées.

2.2. The Israeli concept for runoff and erosion in semi-arid zones in the Mediterranean basin

Auteurs: M. Agasi, Y. Benyamini, J. Morin, et S. Marish
Soil Erosion Research Station, Rupin Institute Post, Emek-Hefer, 60960, Israel

E. Henkin
Head of the Division of Soil Conservation and Drainage, Ministry of Agriculture, Hakiria Tel-Aviv 61070, Israel

Cette étude représente une synthèse des recherches expérimentales des

processus d'érosion dans de différentes régions d'Israël, pendant les 20 dernières années. Les recherches réalisées pendant plusieurs années ont démontré que l'équation universelle de la perte des sols (EUPS) ne peut pas être appliquée en Israël, ni intégrée dans leurs modèles de coefficient de délivrance. L'approche israelienne au problème de l'érosion hydrique est axée sur une analyse des rapports entre les précipitations et les caractéristiques physiques et chimiques de différents sols, avec l'application des méthodes de laboratoire et des méthodes in situ.

Un réseau de stations météorologiques, d'une densité de 1 station de non-enregistrement tous les 15 km^2 (plus de 700) et de 1 station d'enregistrement tous les 150 km^2 (environ 80) a servi de source de données sur les précipitations. La période d'observation a été de 30-50 ans.

La base d'analyse des caractéristiques des précipitations était la quantité de précipitations dans la période de temps pendant laquelle les intervalles entre les segments de précipitations ne dépassent pas 24 heures. Etant donné que les méthodes de prévision sont basées sur les informations météorologiques antérieures, chaque analyse de probabilité est incertaine, et pour cette raison les auteurs ont appliqué plusieurs méthodes simultanément. Dans une analyse des précipitations, on a défini la quantité, l'intensité et l'énergie cinétique de la pluie. La meilleure corrélation avec l'apparition d'averses a été démontrée par l'énergie cinétique exprimée comme valeur R de l'équation EUPS.

Le ruissellement de surface consécutif à une averse donnée est fonction du degré de la possibilité d'infiltration des sols, de la capacité de rétention superficielle, de l'intensité de la pluie, de sa distribution et des séquences. La croûte superficielle (1 mm), formée dans beaucoup de régions semi-arides par suite de l'impact direct des gouttes de pluie et de l'effet de dispersion de l'ion Na + échangeable, représente le principal facteur qui régit le degré d'infiltration.

Le pourcentage minimal de l'ion Na - ESP 1-2%, conditionne la peptisation de l'argile et la formation de la croûte superficielle, ce qui réduit sensiblement le degré d'infiltration. Pour ce degré d'infiltration, on avait mis au point un modèle mathématique de prévision par la combinaison de l'équation d'infiltration avec une analyse des averses avec le facteur d'accumulation et de rétention superficielle (RS). La comparaison entre le ruissellement superficiel supposé par ce modèle et celui mesuré réellement démontre une haute corrélation. Ce modèle peut être appliqué pour les prévisions de ruissellement dans de petits bassins (2-3 ha).

De vastes expériences ont été effectuées à l'aide d'un simulateur de pluie en laboratoire (boîtes 30 x 50 x 10 cm) et sur des parcelles de champs (1,5 m^2), ainsi que par les mesures du ruissellement effectuées sur les sections exposées aux précipitations naturelles (5 x 20 m et 9 x 100 m). Ces méthodes ont permis d'observer les effets des mesures agrotechniques sur le ruissellement et sur l'érosion du sol. Les essais de l'influence de 10 différents types de traitement sur le degré d'infiltration ont démontré que le degré d'infiltration le plus important a été atteint dans les opérations provoquant la formation d'agrégats plus grossiers. Ces résultats ont été testés sur des parcelles de champs (25 x 6 m), dans lesquelles on a ajouté les variantes de traitement sur sillons, lesquelles augmentent la rétention et réduisent le ruissellement d'une manière considérable. Toutes ces expériences montrent que les types de traitement, augmentant le degré d'infiltration et la rétention (RS), provoquent une réduction des averses de 60-70% par rapport au témoin.

Pour empêcher l'influence de la peptisation du sodium, on avait appliqué le phosphore-gypse (produit secondaire dans l'industrie des engrais phosphatés) en plusieurs variantes. Par un répandage de 5 t. de PG sur la superficie des sols, le ruissellement a été réduit de 75%. En augmentant le degré d'infiltration de 3 mm/h en contrôle à 10 mm/h sur les sections traitées, cette mesure s'est avérée très efficace, étant donné que presque 80% des averses en Israël ont une intensité inférieure à 8 mm/h. L'effet positif du PG agit pendant le temps dans lequel celui-ci reste en concentration suffisante pour assurer la floculation de l'argile.

Les conditions climatiques dans lesquelles ces expériences ont été réalisées sont typiquement méditerranéennes, soit 400-800 mm de précipitations réparties pendant les mois hivernaux. Les types des sols utilisés pour les expériences représentaient le groupe de sols agricoles les plus importants en Israël (luvisol calcique, luvisol vertique, luvisol chromique, vertisol chromique). Analysant les conditions climatiques de la Méditerranée, les auteurs ont conclu que ces résultats peuvent être appliqués dans le sud-ouest de la Méditerranée, à l'est de la zone côtière méditerranéenne de la Turquie, à Chypre et en Crète, en Grèce du sud, Italie du sud, Sicile, Sardaigne et Espagne du sud.

Pour assurer le succès de la coopération, estimée indispensable, les auteurs suggèrent l'organisation d'un Comité de travail dont les objectifs seront les suivants:

- formuler les principes pour la définition des problèmes et la normalisation des méthodes, organiser la collecte et le traitement commun de données obtenues sur les sections où sont effectuées les mesures;

- constituer 2-3 centres de recherche chargés de l'analyse des rapports, des précipitations et du ruissellement à l'aide d'un simulateur de pluie pour tous les pays méditerranéens;

- normaliser les méthodes de collecte et de traitement des données météorologiques;

- unifier la classification des sols;

- organiser des stages de formation de cadres et des réunions d'experts.

2.3. <u>An integral approach to catchment management in Italy</u>

Auteurs: F. Mancini et S. Graci
Istituto Sperimentale per lo Studio de la Difesa del Suolo, Firenze, Italy

Dans la zone côtière italienne les 4/5 du territoire sont envahis par l'érosion. Le degré de proportion des phénomènes d'érosion est en correspondance avec les migrations de la population. Les terrains montagneux, peuplés depuis la période préhistorique, ont été, jusqu'à la première moitié du XXème siècle, exposés à la dévastation des forêts, à un surpâturage et à l'utilisation inadéquate des terres agricoles. Ceci a eu comme résultat une fréquence élevée d'inondations catastrophiques avec le dépôt de quantités énormes de sédiments. Sur la base des documents historiques, il a été noté jusqu'au XVIe siècle une fréquence de 6 à 7 inondations par siècle, laquelle est ensuite en hausse pour atteindre 20 inondations au XVIIIe siècle.

La lutte contre l'érosion a une longue tradition en Italie, et au cours de dernières décennies on a développé et arrêté la conception de l'aménagement intégré des bassins versants. La réalisation desdites mesures a été confiée à un service régional unique "Comunita Montana", tandis que les projets sont réalisés par les équipes de spécialistes de différentes disciplines, ingénieurs, géologues, pédologues, forestiers, agronomes et économistes. La législation adéquate donne un grand appui à la réalisation de cette activité.

Dans le but de présenter les expériences dans le domaine d'une telle approche au problème de la protection des sols, les auteurs ont choisi le bassin versant de la rivière Staggia (47,6 km^2), un affluent de l'Arno (province de l'Arezzo en Toscane). Il s'agit d'un bassin typique des monts Apennins, composé de grès et de siltanés, avec quelques marnes calcaires et argilo-schisteuses. Le type prédominant est le cambisol districque à textures différentes. La végétation dans la partie supérieure du bassin versant est composée du hêtre, du tilleul, de l'orme et du sapin, tandis que la région basse abonde en chênes. La température moyenne annuelle est de 12-13°C dans les plaines et de 7-8°C dans les montagnes. La quantité totale des précipitations s'établit à 1300-1800 mm, et la courbe de l'intensité de précipitation explique la fréquence des inondations. Les inondations catastrophiques en 1926 et 1927 ont conduit à prendre dans ce bassin des mesures de protection radicales et plus larges.

Les travaux forestiers ont compris la conversion des forêts basses et le reboisement, avec la consolidation du terrain. Ceci a permis d'augmenter la superficie forestière de 55% (1930) à 89%.

Cette augmentation des superficies forestières a été possible grâce à l'abandon des terres agricoles et à la migration de la population vers les centres industriels. Les régions montagneuses ont gardé seulement des fragments des terrains agricoles et des pâturages, dans le but de sauvegarder le gibier. Le boisement des terrains a été effectué en recourant à des techniques spécifiques de lutte anti-érosion, par les espèces suivantes: sapin argenté, pin de Corse et Pseudotschuga duglasii, avec le hêtre, le marronnier et le chêne.

Les travaux hydrologiques ont compris l'érection de 59 barrages dans tous les affluents de micro-bassins versants, dans le but d'empêcher le sillonnage des lits de torrents et de consolider les pentes, ainsi que d'arrêter le transport de sédiments par la réduction des vitesses d'écoulement. On a également appliqué d'autres procédés techniques dans les lits de torrents.

Les effets positifs de ces travaux sont très convaincants. Les pentes sont complètement stabilisées par les forêts denses, de même que le réseau hydrographique, et la quantité moyenne de sédiments transportés a été réduite de 565 t/km^2 à 360. Les auteurs soulignent l'importance de l'entretien des ouvrages construits, pour pouvoir préserver les effets obtenus.

2.4. L'impact de l'aménagement des forêts sur la protection des sols et de l'environnement au Maroc

Auteurs: M. Azeba et F.A. Filali
Service des Eaux et forêts, Direction Provinciale de l'Agriculture, Al Hoceima, Maroc

La dévastation de la couverture forestière et la dégradation du système écologique, commencées à l'époque de la colonisation, continuent encore

aujourd'hui, à cause d'une énorme pression démographique avant tout. Les besoins en bois, les incendies de forêts, ainsi que le surpâturage provoquent une érosion importante des sols, ayant les conséquences négatives suivantes:

- perte des terres productives;

- modifications infrastructurelles (remblayage d'accumulations, dégradation des chemins, augmentation de la fréquence des inondations, perturbation du régime des eaux souterraines, dégradation du réseau d'irrigation, remblayage des ports, dégradation du paysage, régression de la faune).

Lors de l'amélioration des bassins de drainage, on insiste sur l'aménagement intégral du bassin versant, le facteur socio-économique étant celui que l'on prend le premier en compte.

Comme exemple de la mise en oeuvre d'une telle conception, la présente étude propose l'amélioration du bassin du Neckor (78.000 ha), caractéristique de la partie est de la chaîne montagneuse du Rif. Ce bassin est caractérisé par la prédominance des substrats de schiste et de grès s'étalant de 120 m (site du barrage) à 2000 m dans l'arrière-pays montagneux. Les pentes de plus de 50% représentent 40% de la superficie totale, et les pentes de moins de 20%, 18%. Les sols sont faiblement développés et plats, à l'exception de rares terrasses ayant gardé un sol plus profond. Le climat est du type méditerranéen avec une variation de précipitations de 300 mm dans la vallée à 1000 mm dans la région montagneuse.

Dans la région bioclimatique de l'olivier-lentisque, la partie inférieure aride est occupée par la végétation xérotherme avec prépondérance du thuya, tandis que dans les régions plus hautes le <u>Quercus ilex</u> prédomine. Toutes ces conditions font que le bassin du Neckor est fortement exposé à l'érosion (3.500 t/km^2 par an).

Les méthodes d'aménagement du bassin versant reposent sur la classification des sols, en prenant en compte le relief, les propriétés physico-chimiques du sol, l'état de la végétation, l'agressivité du climat et le degré de la présence de l'érosion active et possible. Le critère essentiel dans la classification du bassin est la succession des conditions phytoécologiques, étant donné que les mesures biologiques, surtout le boisement, représentent l'activité prioritaire dans le cadre des mesures d'amélioration. Les mesures mécaniques ont avant tout pour rôle de permettre un boisement réussi des terrains érodibles et de protéger directement, à bref délai, le système écologique contre les conséquences nocives de l'érosion. L'arboriculture traditionnelle est également encouragée par la distribution gratuite des plantes fruitières aux exploitants agricoles, dans le but d'assurer leur participation à l'action, bien que la fonction antiérosive de ces cultures soit inférieure à celle des forêts. Cependant, ceci représente un compromis indispensable, dont les conséquences sont atténuées par l'aménagement de terrasses et d'autres ouvrages antiérosifs. Alors que l'arboriculture est privilégiée sur les terrains bien drainés, la vigne et les pâturages sont recommandés sur les sols plus durs. Les gazons sont disposés sous forme de bandes et cette forme de protection biologique est assez répandue. Une succession de terrains boisés dans la zone côtière a une portée écologique plus vaste, y compris le renouvellement de la population des oiseaux. L'efficacité des mesures dépend de la coopération de la population locale dont les intérêts sont déterminés par l'enquête.

Le bassin du Neckor a été déclaré bassin versant d'intérêt national, étant donné que les résultats qui y ont été obtenus devront servir de modèle pour les autres bassins similaires du Maroc. Les travaux dans ce bassin ont été entrepris en 1950 et durant la réalisation du projet Derro (à partir du début de 1963) les mesures suivantes ont été prises:

(a) les surfaces boisées ont été augmentées de 2% à 12%. A cette occasion on a choisi des espèces déjà communément cultivées en prenant en compte leurs fonctions de protection et de production. La fonction de la protection a été confirmée, tandis que celle de production devrait être valorisée. La préparation des sols ainsi que les travaux correspondants ont assuré un succès du boisement;

(b) en ce qui concerne l'arboriculture, les espèces prédominantes sont: amande, olive, figue, poire, pomme et prune. Dans le cadre de cette culture, les différentes mesures de protection sont appliquées en fonction de la topographie et du substrat (haie vive en bordures des parcelles, murs en pierres, micro bassins de retenue d'eau, etc);

(c) dans le cadre de l'amélioration des pâturages, l'activité principale est orientée vers la réalisation de gazons permanents de bandes herbacées, la plantation d'arbres, le remplacement des terres en friche par les plantations de pâturages;

(d) les travaux mécaniques ont eu pour but la maîtrise des mouvements d'alluvions érosives en vue de protéger l'environnement à bref délai, moyennant l'aménagement de différents types de barrages. Ces mesures se sont avérées insuffisamment efficaces en l'absence de l'application de mesures biologiques;

(e) la construction de 180 km de routes, d'écoles, de dispensaires et d'autres ouvrages, ainsi que les investissements importants ont contribué au développement économique et à la hausse des offres d'emplois.

En procédant au bilan, les auteurs soulignent surtout la nécessité d'un aménagement intégral des parties amont et aval du bassin, ce qui nécessite l'intégration d'une partie plus vaste de l'arrière-pays côtier dans la planification.

3. APERCU D'ENSEMBLE SUR LES ETUDES DE CAS

L'érosion due à la pluie dans les zones côtières de la plupart des pays méditerranéens a de telles proportions qu'elle déborde du cadre des problèmes locaux et nécessite une intervention au niveau national. Ce problème doit faire l'objet d'une grande attention de la part de vastes collectivités, étant donné qu'il ne s'agit pas uniquement d'une perte irrévocable et considérable des ressources naturelles, mais aussi de conséquences de l'érosion ayant un effet négatif sur les ressources d'eau, sur les systèmes d'irrigation, sur les routes, agglomérations et ports, avec même un impact sur les rapports socio-économiques dans un rayon plus étendu.

Le programme national de la protection des sols contre l'érosion doit être fondé sur les informations réelles concernant l'extension, la forme et l'intensité de l'érosion. L'inventaire des formes et de l'intensité de l'érosion due à la pluie et du risque d'érosion sous forme de cartes

d'érosion, représente le niveau d'informations primaires indispensable à la réalisation des programmes de protection des sols au niveau national et régional.

Ici, il faut distinguer deux types de cartes d'érosion. Le premier type peut présenter la forme d'érosion et le degré de son intensité qui ne sont pas évalués sur la base des conséquences évidentes, à savoir selon les tendances de perte des sols par rapport à la normale. Il s'agit en effet d'un état statique au moment des levés. Un deuxième type de cartes, pouvant être intitulé "dynamique", donne une estimation du degré d'érosion possible dans des conditions déterminées, soit l'érodabilité des sols ou le risque d'érosion.

Pour ce colloque, on avait présenté l'expérience de la Turquie dans le domaine de l'établissement et de l'utilisation de la carte d'érosion du premier type. Cette carte a été obtenue à titre supplémentaire lors de l'établissement de la carte pédologique, étant donné que le programme de levés comprenait aussi l'identification de la forme et du degré d'érosion des sols pour chaque unité cartographique. L'interprétation d'une telle carte a permis l'établissement d'une carte d'érosion à l'échelle identique ou réduite. Cependant, la valeur de cette carte est limitée comme le démontrent l'expérience turque. En mettant en évidence le degré de ce phénomène et l'importance des dégâts, elle peut susciter l'intérêt de l'opinion publique et inciter les institutions qualifiées à prendre en compte le problème d'érosion lors de la planification nationale et régionale et lors de l'allocation des moyens correspondants pour la lutte contre l'érosion. Ici aussi les valeurs d'utilisation de cette carte sont presque épuisées. La réalisation de cette carte ne peut être justifiée que dans le cas où elle représenterait un complément de la carte pédologique, ou dans le cas où elle serait établie à l'aide des moyens techniques modernes dans une intervalle de temps relativement court. A cet effet, l'échelle de la carte choisie en Turquie (1/1.000.000) nous paraît suffisante.

La carte d'érosion potentielle, dans laquelle les unités cartographiques sont distinguées en fonction du degré d'érodabilité des sols, exprimé en quantité de la masse de terre (t/ha) mise en mouvement par l'érosion au cours d'une année, a une valeur beaucoup plus importante. Cette carte offre les meilleures bases pour une prise de mesures préventives dans le sens d'un choix optimal des modalités d'utilisation des sols et du type de culture, ainsi que pour les études des mesures techniques contre l'érosion. Une telle carte a été réalisée pour l'Afrique du Nord et pour le Moyen-Orient, par la FAO, le PNUE et l'UNESCO, à l'échelle 1/5.000.000. D'après les rapports nationaux, ces cartes sont disponibles en Turquie et en Libye.

Vu la situation existante, la proposition exprimée dans l'étude de cas turque, c'est-à-dire de réaliser une carte d'érosion de la zone côtière méditerranéenne entière par une méthode unifiée, nous paraît très justifiée. Cette base permettrait un transfert de savoir et d'expérience très efficace et très fiable. Bien sûr, il faudrait profiter des possibilités offertes par une interprétation moderne de la technique de levés par satellite.

L'établissement d'une telle carte suppose l'existence de modèles de prévision, dont la valeur serait vérifiée dans les conditions méditerranéennes spécifiques. Pour l'évaluation du risque d'érosion, actuellement on applique au maximum l'Equation universelle de la perte des sols (EUPS) qui sous-tend la méthode de la FAO (Guidelines for soil degradation Assessment, 1979). Cependant, les expériences de la plupart des pays méditerranéens démontrent

que ce modèle ne peut pas être appliqué dans les conditions des zones côtières méditerranéennes. Ceci a été précisément confirmé par de nombreuses expériences réalisées en Israël. A part cette incompatibilité avec les conditions méditerranéennes, cette méthode suppose un niveau de recherches et des données dont disposent uniquement les pays développés. En ce qui concerne l'érosion en ravine, une méthode universelle n'existe pas. C'est la raison pour laquelle la mise au point d'une méthode simplifiée d'évaluation de l'érodibilité des sols représente une tâche d'actualité pour les pays méditerranéens.

La mise au point d'un modèle de prévision et la programmation des mesures contre l'érosion, impliquent la meilleure connaissance des mécanismes d'érosion et des facteurs qui les conditionnent. Les recherches dans ce sens ont été réalisées en Israël, surtout au cours de la dernière décennie. Les résultats desdites recherches ont été présentés au cours de ce colloque comme étude de cas. Les expériences acquises dans ce domaine démontrent:

- que l'objet de ces recherches doit être clairement défini;

- que, dans la méthode de recherche, il faudrait combiner les essais en laboratoire avec les expériences réalisées sur les parcelles de champs à l'aide d'un simulateur de pluie, ainsi que sur les parcelles Wishmayer avec les précipitations naturelles;

- que pour une analyse de la probabilité d'averses il faut appliquer plusieurs modèles, étant donné que la fiabilité de certains d'entre eux est relativement faible;

- que les résultats de ces essais peuvent être largement utilisés si les conditions d'expérience ont été bien définies.

Les résultats acquis à travers ces recherches ont un niveau scientifique élevé et une vaste portée pour la Méditerranée. Ils devraient permettre d'accélérer la lutte contre l'érosion dans les régions semi-arides de la Méditerranée.

Les modèles de prévision méritent une attention particulière, étant donné qu'ils ont été testés dans les conditions méditerranéennes, et sont basés sur les rapports entre l'énergie de la pluie et les caractéristiques des sols, ce qui simplifie la méthode et réduit le nombre d'informations nécessaires.

Pour cette raison, ces modèles sont accessibles à un grand nombre de pays. Les essais de ce modèle dans les zones côtières méditerranéennes pourraient permettre d'uniformiser l'approche du problème et d'obtenir une application plus rapide des modèles adéquats.

Certains résultats des recherches israéliennes peuvent être appliqués dans toutes les zones semi-arides de la Méditerranée, à commencer par l'application de phosphore-gypse sur tous les terrains ayant une teneur en ion Na + échangeable augmentée, et qui sont sujets à l'érosion. L'introduction des mesures agrotechniques assurant la constitution d'agrégats grossiers représente aussi une connaissance pouvant être directement appliquée. Cependant, le plus grand avantage pour cette action méditerranéenne générale serait l'introduction de ces méthodes et types d'expériences dans les programmes de recherche méditerranéens correspondants. Ceci pourrait permettre la modernisation du niveau d'expérience et l'acquisition relativement rapide d'informations indispensables pour une lutte efficace contre l'érosion.

La méthode la plus efficace de la lutte contre l'érosion et de protection de l'environnement serait une approche intégrale de l'aménagement des bassins versants. Le bassin versant est un système dynamique, socio-économique et physique intégré, comprenant la population, l'agriculture, l'industrie, les communications, etc. Chacune de ces activités peut perturber l'équilibre du système. L'abattage des arbres, par exemple et la construction des routes peut entraîner une perte du couvert végétal, ce qui augmente l'écoulement des eaux superficielles, et provoque une érosion ayant une grande influence sur la qualité d'alimentation en eau et sur la pollution des eaux. Le but de l'approche intégrée de l'aménagement des bassins versants consiste en l'utilisation et la gestion coordonnées des terrains, des eaux, végétation et autres ressources physiques et activités à l'intérieur du bassin versant, en vue de réduire la dégradation et l'érosion des sols au minimum, avec un impact négatif minimum sur la qualité de l'environnement. Actuellement, ceci représente une tendance très en vogue dans le monde entier et il est très utile que plusieurs pays méditerranéens s'emploient à appliquer une telle approche.

S'agissant des zones côtières méditerranéennes, il faut souligner le fait que dans cette région on rencontre plusieurs types de bassins de drainage et des modèles différents de leur aménagement intégré. En Italie, par exemple, la plupart des bassins ont les caractéristiques suivantes:

- abandon des terres agricoles à cause de la migration de la population vers les zones industrielles et de la conversion de ces terrains en zones forestières;

- l'agriculture est conservée uniquement sur les terres fertiles dans les vallées des cours d'eau, dans lesquelles le problème d'érosion ne se pose pas jusqu'à présent;

- le boisement est réalisé sur la base des recherches préalables, des diverses études cartographiques et d'autres documents techniques;

- le processus de boisement avait commencé il y a quelques décennies, et dans beaucoup de bassins on retrouve les terrains à différents stades de reboisement, ce qui permet une évaluation des résultats;

- le boisement est suivi de travaux mécaniques dans le bassin versant, dans le but de stabiliser les terrains et le réseau hydrographique.

Dans les pays d'Afrique du Nord, les bassins de drainage ont les caractéristiques suivantes:

- dans un même bassin, on retrouve plusieurs types d'utilisation des terrains, ce qui exige de concilier différents intérêts;

- l'érosion est présente sous différentes formes et intensités, ce qui implique l'application de mesures différentes de protection;

- la pression démographique favorise l'extension des terrains forestiers et l'apparition de nouvelles causes d'érosion;

- la nécessité de protection de toutes les ressources est ici très marquée, étant donné que la perte des terres provoque la sédimentation des cours d'eau et des bassins, fait peser une menace sur les ports, habitations et communications, avec des conséquences socio-économiques très graves;

- les travaux d'aménagement des bassins versants et l'intégration de toutes les activités ne sont pas suffisamment mis en valeur.

Etant donné la variété des conditions naturelles et économiques et des expériences, il serait indispensable d'établir une étude de synthèse concernant cette activité et d'organiser des stages d'entrainement sur les localités représentant des modèles typiques de bassins de drainage en Méditerranée.

4. PREPARATION DU PROJET DE COOPERATION

Sur la base des recommandations données au cours de la réunion d'experts, il a été préparé, en coopération avec la FAO, un plan du projet de coopération sous le titre : "Monitoring and Assessment of Rainfall Induced Erosion in Mediterranean Coastal Zones". Il a été mis une dernière main à ce plan au cours de la réunion ACSAD, au titre de proposition CAR/PAP/FAO/ACSAD.

Le projet de proposition part des faits suivants:

- l'érosion due à la pluie est la forme de dégradation des sols la plus répandue et la plus importante dans les zones côtières méditerranéennes. Malgré le fait que les phénomènes d'érosion et leurs processus sont bien connus, la compréhension des caractéristiques méditerranéennes spécifiques est insuffisante, et les données limitées concernant le phénomène, recueillies par différentes méthodes d'approche, sont très souvent incompatibles.

- pour arriver à augmenter le savoir spécifique nécessaire, il faudrait intensifier les mesures des paramètres des processus d'érosion, unifier les méthodes et coordonner les activités. Ce sont là des perspectives indispensables pour parvenir à l'avenir à une coopération dans le domaine de l'étude et de la réalisation de mesures contre l'érosion et de la formation de cadres.

L'objectif du projet à long terme est d'améliorer la protection contre l'érosion due à la pluie dans les zones côtières méditerranéennes.

Les objectifs directs de cette étude sont les suivants:

- établir un inventaire des situations concernant l'érosion des sols et la lutte contre celle-ci dans les zones côtières méditerranéennes;

- instituer une méthodologie commune et un programme d'observation des phénomènes d'érosion sur les parcelles soumises au ruissellement;

- créer un réseau méditerranéen de procédures de surveillance continue et de stations, ainsi que d'experts en la matière;

- définir un système d'informations en tant que base de traitement de données;

- assurer la formation d'experts locaux participant à cette activité;

- établir un rapport de synthèse et formuler les conclusions, les recommandations et les propositions pour une action future.

On escompte que les résultats du projet seront utilisés par:

- les institutions et experts chargés de la protection des sols dans la Méditerranée pour mieux comprendre les phénomènes d'érosion dans cette région;

- les institutions et experts chargés de la planification et de l'étude des mesures anti-érosion pour augmenter l'efficacité de leur travail;

- les décideurs afin de mieux établir les plans d'activités futures.

Des missions d'experts ont été réalisées jusqu'à présent en Syrie, Italie, Tunisie et Algérie.

Les informations récoltées au cours de ces missions ont démontré ce qui suit:

- dans tous les pays visités, on a donné un soutien complet à la proposition de projet, et l'action elle-même a été estimée d'un intérêt commun, tant pour certains pays que pour l'ensemble de la région méditerranéenne;

- il a été confirmé que l'érosion due à la pluie est très répandue dans les zones côtières, surtout dans les grès et dans les autres sédiments meubles avec des conséquences négatives évidentes sur tout le système écologique;

- en fonction des stratégies du développement économique, dans certains pays lors des recherches sur l'érosion et de la lutte contre elle l'accent a été mis sur les régions continentales, situées en dehors de la zone côtière conformément à la définition précitée;

  etant donné que ces régions sont également exposées à l'influence du climat méditerranéen, les expériences acquises peuvent être prises en considération, mais les stations de mesure situées au sein de celles-ci ne peuvent pas être incluses dans le réseau prévu. D'autre part, si on prend en compte le fait que certains pays (Syrie par exemple) n'ont pas du tout de service de protection des sols, on pourra conclure que l'intensité des recherches et de la mise en oeuvre des mesures contre l'érosion dans les zones côtières méditerranéennes ne répond pas au degré de menace du sol;

- dans la stratégie de lutte contre l'érosion, on ne met généralement pas assez en valeur la nécessité de s'opposer à l'érosion dès son apparition, c'est-à-dire grâce au choix des modalités correspondantes d'utilisation des sols et de cultures appropriées. Certains pays privilégient les mesures mécaniques et le reboisement des sols. Il sera indispensable, dans les expériences futures, d'orienter les efforts vers les recherches de systèmes agrotechniques assurant la meilleure protection des sols contre l'érosion;

- bien que la conception d'une gestion intégrée des bassins hydrographiques existe en théorie, son application pratique en reste très souvent à un degré très faible sur le plan technique, écologique et socio-économique. L'extension d'une approche intégrée de l'aménagement des bassins versants en tant qu'unité de planification et de formation des cadres, est une nécessité actuelle dans les zones côtières méditerranéennes;

- malgré le fait que la plupart des pays possèdent une organisation adéquate pour la protection des sols, ainsi qu'un certain nombre de spécialistes en la matière, il s'avère très souvent nécessaire de désigner des experts pouvant donner leur assistance dans certaines conditions spécifiques comme, par exemple, l'implantation de stations de mesure et l'instauration de méthodes de protection des sols à travers les interventions dans la structure et la méthode de production agricole;

- étant donné le réseau d'installations expérimentales inadéquat dans les zones côtières, la conception initiale de coordination entre les stations de mesure existantes, doit être modifiée et les efforts mis sur l'implantation de stations de mesure. Ceci aura comme avantage l'établissement plus facile d'une méthode unique et l'obtention de la complémentarité du réseau;

- dans le but d'une répartition des stations de mesure plus adéquate, il serait nécessaire d'effectuer un inventaire de la propagation et des formes des phénomènes d'érosion dans les zones côtières méditerranéennes à l'aide de la technique de la télédétection;

- vu que d'après l'approche PNUE il est très important de suivre le déplacement du sédiment érosif, la mesure de la décharge de celui-ci dans le bassin de drainage serait une composante très importante dans le cadre du réseau;

- d'après la situation constatée, il est évident que les tâches principales des stations de mesure devraient consister en la détermination des influences des cultures agricoles et des systèmes agrotechniques sur l'érosion et sur l'apparition des sédiments, pour pouvoir définir les systèmes agrotechniques les plus efficaces;

- l'érosion se produit actuellement surtout dans les régions semi-arides, dans lesquelles la fréquence de pluies érosives est basse. Pour cette raison, outre les mesures des effets érosifs dans les zones de ruissellement, les expériences à l'aide de simulateur de pluie sur le même site et avec les mêmes variantes pourraient donner des informations complémentaires utiles;

- Bien que conscients de l'importance et de la nécessité de l'action proposée, les experts et les autorités des pays visités sont d'avis que, sans un appui financier extérieur, les chances de réussite de cette action sont faibles.

5. CONCLUSIONS

Sur la base des activités réalisées jusqu'à présent, ainsi que sur la base des études de cas présentées dans le présent rapport, nous pouvons avancer les conclusions suivantes.

5.1 Il a été confirmé que l'érosion due à la pluie représente la forme la plus grave de dégradation des sols et que ses conséquences font peser une menace sérieuse sur l'environnement, ainsi que sur le système socio-économique des zones côtières mediterranéennes. C'est la raison pour laquelle ce problème doit être au centre des activités menées dans le cadre de l'action prioritaire "Promotion de la protection du sol comme élément essentiel de la protection de l'environnement de la zone côtière méditerranéenne".

5.2 En ce qui concerne la protection de l'environnement, la même attention devra être accordée aux terrains agricoles dans lesquels prédomine l'érosion en nappe, ainsi qu'aux terrains de pâturage et forestiers, attaqués par l'érosion en ravine; les conséquences se manifestant par une baisse de la productivité des sols, ainsi que par des transferts des sédiments dans le système de l'environnement, sont d'une importance analogue.

5.3 Les connaissances actuelles concernant l'état des recherches sur les processus d'érosion dans les zones côtières méditerranéennes ont démontré:

- que certaines connaissances générales sur l'érosion hydrique ne sont pas applicables dans les conditions méditerranéennes spécifiques;
- qu'à cause des différences existant au niveau du développement des services de protection des sols ou en fonction des priorités nationales différentes, la couverture des zones côtières par les recherches n'est pas adéquate au degré du risque d'érosion auquel sont exposées ces régions;
- que le niveau des recherches et des mesures des paramètres significatifs concernant les processus d'érosion, en tant que base de la lutte contre ce phénomène, n'est pas normalisé, et qu'il dépend du niveau du développement général du pays, de la politique d'utilisation des ressources naturelles et de la tradition.

5.4 Les spécialistes, ainsi que les représentants d'institutions nationales compétentes ont exprimé leur intérêt pour une coopération entre les pays méditerranéens, persuadés que, malgré l'existence de différences locales, la coopération peut être bénéfique pour tous les participants. Toutes les formes de coopération revêtent un intérêt particulier: échange d'informations, colloques et réunions de travail communes, projets conjoints, stages de formation, missions d'experts et assistance technique en équipement.

5.5 L'inventaire des taux, formes et degrés d'érosion, grâce à l'établissement de cartes d'érosion, représente une base indispensable pour le succès de toutes les formes de coopération. Ces bases ont été obtenues dans plusieurs pays méditerranéens, mais par des méthodes différentes et à un niveau professionnel variable. Jusqu'à présent, on n'a pas utilisé les possibilités offertes par l'application de la technique de télédétection pour l'établissement des cartes d'érosion, et cette méthode assure une réalisation rapide et une précision suffisante pour toutes les zones côtières méditerranéennes.

5.6 Pour la mise au point des modèles de prévision du risque d'érosion ainsi que pour l'obtention des données indispensables pour la planification des mesures contre l'érosion, il est nécessaire de poursuivre des expériences intensives sur une période plus longue. Ces recherches sont développées dans certains pays méditerranéens et leurs résultats sont applicables aux régions côtières plus vastes.

5.7 Dans la planification et la mise en oeuvre des mesures de lutte contre l'érosion, s'impose toujours la nécessité d'une approche intégrée de l'aménagement des bassins versants, mais le degré d'application de cette conception est souvent variable. Les obstacles s'opposant à une application rigoureuse de cette conception peuvent être les suivants:

- connaissance insuffisante de cette conception et des méthodes d'intégration de certaines activités;
- sujétion trop forte aux tradtions dans certains secteurs (agriculture, sylviculture, organisation et études techniques);
- difficultés provoquées par le refus de la population locale d'accepter des changements profonds au niveau de l'utilisation des terres et de la rentabilité des exploitations;
- absence des bases nécessaires pour les prévisions de ces actions.

5.8 Le boisement s'est avéré être une mesure efficace pour prévenir l'érosion et restaurer l'écosystème dégradé. Le plus important consiste en un choix approprié des espèces d'arbres, des techniques de boisement des terrains érodés et de la classification de la valeur d'utilisation des sols devant justifier le boisement.

5.9 En ce qui concerne l'aménagement intégré des bassins versants dans les zones côtières méditerranéennes, on a constaté l'existence de plusieurs types nécessitant l'application de différents modèles de solution. L'identification de ces modèles et l'intégration d'expériences pour chacun d'eux pourraient sensiblement améliorer le niveau d'aménagement intégré des bassins versants dans les zones côtières méditerranéennes.

5.10 Les pays méditerranéens en voie de développement ont besoin d'une assistance technique sous forme de fourniture des équipements techniques nécessaires (pluviographes, limnigraphes, simulateur de pluie) ou de l'envoi d'experts pour les aider à la solution de certains problèmes spécifiques, ainsi que sous forme de formation du personnel dans les centres les plus qualifiés des pays méditerranéens.

6. PROPOSITIONS

6.1 Dans le cadre de la mise en oeuvre du programme d'actions prioritaires pour la protection des sols, les problèmes de l'érosion due à la pluie doivent rester au centre des activités menées à l'avenir, en recourant à toutes les formes de coopération citées.

6.2 En vue d'une approche mondiale de tous les facteurs significatifs du phénomène d'érosion, le CAR/PAP devrait examiner les possibilités d'intégrer le problème des incendies de forêts dans le contexte plus vaste d'activités de protection des sols.

6.3 L'activité concrète devra être centrée sur l'élaboration et la réalisation d'un projet de coopération intitulé "Inventory and Network of Soil Erosion Measurement in the Mediterranean for Environmentally Sound Land Management". Le projet ainsi défini, bien que formant un ensemble unique, incorpore trois problèmes significatifs d'érosion due à la pluie: (i) l'établissement des cartes d'érosion en tant que base de prévision d'actions futures et d'échange d'expériences efficace; (ii) la mise en oeuvre d'un réseau coordonné et unifié de stations de mesure dans le but d'assurer une source fiable d'informations nécessaires à une protection moderne des sols; (iii) l'orientation de toutes ces activités vers le développement d'un système intégré d'aménagement des bassins versants en tant que méthode de protection optimale contre l'érosion dans les zones côtières.

6.4 Certaines sections de ce projet unique peuvent être réalisées au titre d'actions distinctes, en fonction des possibilités financières. En conséquence, on propose au CAR/PAP d'entreprendre les actions suivantes au cours de la prochaine période:

- organiser des missions d'experts liées à la réalisation des projets ou à la requête de certains pays, à condition que cette requête s'inscrive dans le cadre de la conception générale du projet;

- identifier et désigner les centres les plus qualifiés pour certaines activités menées dans le cadre du projet et examiner les possibilités de les mettre à la disposition de tous les participants pour des activités spécifiques de recherche et de formation du personnel;

- définir les besoins urgents dans le domaine des équipements indispensables et examiner les possibilités de les assurer aux pays en voie de développement sous forme d'une assistance technique;

- inciter, par les moyens appropriés, et permettre l'introduction des méthodes de levé et de mesure sophistiquées, pouvant permettre d'améliorer la qualité et l'efficacité des activités liées à la réalisation du projet;

- vulgariser par les moyens de communication appropriés la conception de l'aménagement intégré des bassins versants en tant que méthode assurant une protection maximale de l'environnement;

- organiser des réunions de travail dans le but d'améliorer la conception, la préparation et l'application du projet.

MAKING AND USE OF THE SOIL EROSION MAPS IN THE MEDITERRANEAN COASTAL ZONE OF TURKEY

by

M.Y. KILINC
Middle East Technical University
Ankara, Turkey

and

T. CELIKKOL
General Directorate of Forestry
Ankara, Turkey

1. INTRODUCTION

Paramount among man's ecological and environmental concerns are the conservation, protection, development and wise use of natural resources, especially soil and water resources, including the control and assessment of soil degradation, soil erosion and water pollution. Loss of soil through erosion means decreased soil fertility as well as reduced storage in reservoirs and reduced capacity of rivers to carry flood flows because of sedimentation.

Soil is one of the most important bases for the existence of man, animals and plants. Soil degradation as a result of vegetation destruction is a very widespread problem over the earth but it is not yet well understood. Therefore mankind has an obligation to use all natural resources carefully and wisely, thinking of future generations. Mankind should use, not waste; develop not destroy. Conservation and protection does not mean "don't use, conserve", it means "wise, intelligent, optimum use without waste".

An increase in the deterioration of renewable natural resources has become a cause for concern to the United Nations. As a result of recommendations in 1975, FAO, UNEP and UNESCO set up the project : A World Assessment of Soil Degradation, with the following objectives:

(i) to initiate a global assessment of actual and potential soil degradation;

(ii) to develop a methodology and select uniform criteria to measure and monitor soil degradation;

(iii) to prepare guidelines for comprehensive data collection;

(iv) to promote investigations into the utilisation of remote sensing techniques for the purpose of identifying, mapping and monitoring actual and potential soil degradation;

(v) to initiate studies for developing and defining meteorological data which determine climatic aggressivity and soil degradation hazards in different ecological zones.

It was decided that first an approximation of the identification of areas of potential degradation hazard for soil erosion by wind and water and for salinisation-sodification will be made, starting with one area (Africa north of the Equator and the Middle East) as a test case.

One such project, entitled "Promotion of Soil Protection as the Essential Component of the Environmental Protection of Mediterranean Coastal Zones" was undertaken by the United Nations Environment Programme (UNEP), and the Regional Activity Centre for the Priority Actions Programme of UNEP's Mediterranean Action Plan.

In the second phase of this project, the case studies should make possible the elaboration of a comprehensive study on major aspects of protection against soil erosion.

The objectives of this Case Study are:

- to convey the experience gained during both the making and the use of soil erosion maps of Turkey and other auxiliary maps by comparing analysis of coastal zones and continental zones;

- to acquaint the Mediterranean countries with this experience, especially those countries that have not yet made such maps, will prove quite useful;

- to devote and pay equal attention to the experience in drawing the map, concept, methods of work, organisation, choice of scale, limitations, complementary maps in the presentation of this report;

- to explain the use of the map, institutionalisation, organisation, experience and effects.

2. PRESENTATION OF PROBLEMS

2.1 State of erosion in Turkey

The environmental problems of the world have been growing so fast that they threaten human life in spite of environmental control programmes which are considered to be important national tasks. One of the main dangers in the world recently is that of soil erosion, and the resulting degradation and desertification. As a result of biological, chemical and physical deterioration and destruction of environment, steppes and desert lands increase in area. The destruction of forest ecosystems by misuse and fires, loss of soil fertility and loss of productive capacity of land, leads to the creation of steppes or deserts. The degree of land degradation and loss of potential capability of land depends upon the physical, chemical and biological properties of soil.

In Turkey one of the most important environmental problems is that of soil erosion caused by water and wind. Water erosion especially is more dangerous than wind erosion in Turkey. Water erosion does not cause the loss of soil only, but also causes other problems such as flooding, sedimentation, torrents and degradation occurring consecutively as a chain of events. The state of erosion in Turkey became very severe because of surface runoff occurring after rainfall, and also because Turkey is located in the sensitive region of South-Southwest Asia with sparse vegetation cover. It can be noted that Turkey is surrounded by arid and semi-arid climatic regions.

The Mediterranean region of Turkey is situated in the Iranian-Turanian Steppe Zone. The characteristics of arid and semi-arid regions, such as lack of dense vegetation cover, are well-known. Scarce and thin vegetation is a characteristic of this zone. Annex 1 depicts the Erosion Map of Turkey with an original scale of 1:1.000.000. This zone has expanded to the Iran-Iraq-Syria borders including deserts, apart from the Mediterranean coastal zone which has no desert area.

Sediment transport per unit drainage area is very much greater in Turkey than in similar countries in Europe. For instance, Turkey has only 8% of Europe's area, but more sediment discharges occur from Turkish rivers than from any other rivers in the whole of Europe. Recent studies revealed that 72% of land in Turkey has been subjected to severe erosion. As seen in Table I, this ratio is even higher in the Mediterranean zone where 75% of land was subjected to severe erosion. The annual total suspended sediment loss of Turkey is 400 x 10^6 ton. Annual soil loss per $mile^2$ is 1800 tonnes in Turkey, 70 tonnes per $mile^2$ in Europe and 1530 tonnes per $mile^2$ in Asia.

Table I

Land use and erosion cover in the Mediterranean zone of Turkey

Province name	Area (ha)	Area subject to erosion (ha)	Proposed land use	
			from agriculture to range (ha)	from agriculture to forest (ha) (eroded area)
Aydin	806.915	635.896	9.190	4.725
Balikesir	1.452.814	1.151.102	261.034	-
Hatay	540.261	288.279	20.292	26.000
Adana	1.725.267	1.071.296	56.000	70.314
Izmir	1.201.819	818.468	-	10.000
Antalya	2.059.067	1.461.250	89.809	-
Mugla	1.250.400	1.063.315	12.000	-
Icel	1.585.259	848.869	75.000	75.000
Total (ha) :	10.621.802	7.338.475	323.325	186.039
Percent (%) :		(69%	+	6%) = 75%

Areal distribution of the water erosion state based on Land Capability Classes of Provinces in Mediterranean Coastal Zone is tabulated and given in Table II.

Table II

Areal distribution of water erosion state of Mediterranean provinces

Province name	Moderate erosion (ha)		Severe erosion (ha)		Very severe erosion (ha)		Total (ha)	
	Land Cap. Class		Land Cap. Class		Land Cap. Class		Land Class	
	II-III-IV	V-VI-VII	II-III-IV	V-VI-VII	II-III-IV	V-VI-VII	II-III-IV	V-VI-VII
Adana	181 331	21 653	46 781	526 064	-	259 467	228 112	843 184
Antalya	128 023	3 986	30 915	464 843	-	833 483	158 938	1 302 312
Aydin	82 669	6 838	2 984	399 362	499	139 847	86 152	546 047
Balikesir	157 019	12 347	45 502	915 733	-	20 411	202 521	948 491
Hatay	71 603	21 703	7 352	149 017	-	38 599	78 955	209 319
Icel	100 336	32 938	27 117	510 907	-	175 066	127 453	718 911
Izmir	14 206	8 178	32 636	488 310	-	275 138	46 842	711 626
Mugla	99 834	6 453	11 243	694 189	-	251 596	111 077	952 238
Percent								
Total (ha)	850 021	114 096	204 530	4 148 425	499	2 029 607	1 104 050	5 292 128

2.2 Main erosion factors in the coastal zones

In the Aegean Sea of the Mediterranean zone, annual sediment loss from Büyük Menderes basin through Büyük Menderes River is 212 ton per km^2. Rivers running towards the Mediterranean Sea are shown in Annex 2.

Severe water erosion and floods have occurred for a long time in this region. During the period 1953-1977, 20 lives have been lost annually due to floods, and 1.623.400 ha of fertile land has been damaged by flooding. Moreover the infrastructure, with its subsidiaries, cities, towns and villages, have been damaged. In the Five Year State Plan, 121.220 billion m^3 debris was expected to be cleaned from the irrigation channels and from the stream beds at a cost of 35 Billion Turkish Lira, as shown in Table III. In this region of the Mediterranean zone, nine dams and their reservoirs are in operation. Over two years' observation, sediment discharges were about 456.6 m^3 (1400 tons) per km^2 per year. One of the major dams on the Seyhan river of the Mediterranean coast lost 46% of its capacity within 26 years. All these facts show that severe erosion has been occurring for a long time in this coastal zone of the Mediterranean.

One of the main reasons why erosion occurs is misuse of vegetation and land. The removal and destruction of protective plant cover causes flash floods and consequently erosion occurs with all its harmful effects.

The rough terrain and relief of the Mediterranean zone retards the deep soil formation but topographic conditions accelerate the erosion and surface runoff. The soil and vegetation of these zones are sensitive to deterioration. To understand the dynamics of erosion and sedimentation of flooding in a better way, it is helpful to consider the background to Land Use in Anatolia. The first stage of the Anatolian erosion commenced at the time of the Roman conquest, with the use of forest trees for shipbuilding. The Romans and the Macedonians used forests and forest land for purposes of mining, shipbuilding, resin production and expansion of agricultural into forest land. Another factor which had an impact on the land was the migration of people toward the newly-conquered land from other parts of the Hellenic and Roman Empires. The erosion process thus slowed down with the settlement of people, except during the disturbances and the wars among the nations of Anatolia.

The second stage of the erosion period started at the end of the Ottoman Empire when the authority of the Empire became weak and powerless.

The third stage of the erosion period in Anatolian lands started after the 1950's with the start of agricultural technology. The selection of inappropriate machinery for agriculture and the use of non-agricultural land created new erosion problems. Sloping land was cultivated easily by means of the new machinery. The increase of population put more pressure on agricultural lands which are sensitive to erosion.

In general, soil, topography, geology and vegetation are natural factors which do not accelerate erosion without human interference. Whenever human beings misuse the land and vegetation, soil is removed and sediments are carried down to the lowlands and rivers. The fertility of surface soil will be reduced rapidly and the lowlands will be covered with sedimentation.

Table III

Dredging and cleaning of the debris and sediments from irrigation and drainage channels over five years

Type of channels to be dredged	Sediment removal for given years					Total Sediment removed (10^3 m^3)
	1980 (10^3 m^3)	1981 (10^3 m^3)	1982 (10^3 m^3)	1983 (10^3 m^3)	1984 (10^3 m^3)	
Lined channel cleaning	1 633.	2 739.	2 665.	3 885.	4 166.	15 088.
Main and secondary collectors	6 776.	5 711.	6 217.	9 296.	7 711.	35 711.
Drainage channels	5 982.	7 827.	4 848.	4 784.	14 444.	37 885.
River beds	2 088.	828.	7 110.	11 125.	11 386.	32 573.
Total (10^3 m^3):	16 479.	17 105.	20 840.	29 090.	37 707.	121 221.

Note: Total cost of dredging and cleaning was 35 Billion Turkish Lira (TL). This amount of Turkish Lira was about equal to 55 million dollars.

Along the coastal line of the Mediterranean zone, especially along the coastal strip, the land capability classification and actual existing land use were studied in the provinces of Hatay, Adana, Mersin, Antalya, Izmir and Balikesir. According to this study there are 442.406 ha of Class VI and VII land, which are not suitable for agriculture along the coastal zone. Class III and VII land should be kept under continuous vegetal control, otherwise erosion will occur immediately. In Table IV, distribution of land capability classes are given for the Mediterranean provinces.

The principal causes of erosion along the coastal line are forest fires and the converting of forest land into temporary agricultural land. These forest lands are located on the hinterland of the coastal zone. Agricultural land gained from forest land cannot last long because of unprotected agricultural practices. There are two reasons for erosion problems in these converted areas: (a) these lands are not suitable for cultivation, therefore they are sensitive to erosion because of uncovered and steep slope conditions, (b) they are cultivated without soil conservation measures. Consequently, the converted forest land of the hinterland has become the sediment source of the coastal zone. Moreover social and economic problems of the zone is increasing as a result of the decrease in productive land.

Parent material is also another cause of erosion because of its susceptibility to detachment and erosion. The geologic properties of parent material in these areas appear loose and permeable which may result in easy disturbances, landslides and collapses. Rocks of the Mediterranean zone were formed during the Cretaceous, Palaeocene, Neocene, Quarternary and Volcanic ash and Tuft formations. They are therefore vulnerable to erosion and erodible soils can develop over these rocks.

Animal grazing is another factor which can cause erosion and flooding. Trampling by cattle causes the compaction of the soil; this reduces the infiltration rate and retards the regeneration of plants, resulting in flash-floods and erosion.

Erosion caused by water starts off as sheet erosion but soon rills develop and then gullies are carved out. Consequently deep gulleys occur with huge amounts of sediment transportation, resulting in a massive movement of soil and landslides. Besides the loss of crop land and residential areas due to sediment deposition, there is the loss of capacity of channels and reservoirs due to sediment discharges all generated from the destroyed uplands and forest lands.

2.3 Consequences of erosion in the coastal zones

Sedimentation has occurred since the beginning of time in this region of the Mediterranean zone. In Table V sediment discharges of Mediterranean rivers are given. Erosion and sedimentation filled the sea ports and new deltas were formed. Some historical seaports were abandoned as a result of erosion and sedimentation, for instance, Milet City and Ephesus City on the mouth of Küçük Menderes (small meandering river) and on the mouth of Büyük Menderes (great meandering river) respectively. Along the coastal strip many ruins of arenas, theatres, gymnasia, libraries, sport fields, streets, avenues and temples were found under the sediment deposition from upland and forest erosions. The ancient City Milet is now about 10 km from the shores of the Mediterranean. This city was a sea port for the hinterland of the zone.

Table IV

Distribution of land capability classes for Mediterranean provinces

Province name	Cultivated land			Total	Cultivated at risk	Non-cultivated land			Total	Barren Land
	Class I	Class II	Class III		Class IV	Class V	Class VI	Class VII		Class VIII
Adana	239 725	118 087	112 401	470 213	123 473	1 745	149 614	882 248	1 033 607	82 040
Antalya	93 312	109 487	76 088	278 887	54 820	30 958	166 325	146 080	1 343 363	378 970
Aydin	54 297	49 171	73 884	177 352	48 060	-	102 802	464 298	567 100	6 101
Balikesir	47 999	126 639	80 731	255 369	85 833	387	231 349	851 995	1 083 731	9 662
Hatay	70 917	49 031	52 245	172 193	28 886	538	50 391	277 596	328 570	4 061
Içel	44 583	41 778	55 225	141 586	45 753	283	162 291	1 097 340	1 259 914	86 252
Izmir	117 931	95 134	87 003	300 068	72 325	-	155 952	656 141	812 093	16 068
Mugla	37 984	50 510	59 941	148 345	40 318	-	130 106	862 944	992 950	59 037
Percent				18.3%	4.7%				70%	6%
Total:	706 748	639 835	597 518	1 944 013	499 468	33 866	1 148 830	5 238 642	7 421 328	641 191

Table V

Sediment discharges of rivers with hydrologic stations of the Mediterranean zone of Turkey

Station Number	River Name	Station Name	Drainage Area (km^2)	Annual Sediment discharge (Ton/year)	Sediment * Yield (Ton/yr/km^2)	Correlation Coefficient
818	Gediz N.	Manisa Köprüsü	9 615	728 260	76	0.83
601	K. Menderes N.	Selçuk	3 277	226 149	90	0.96
701	Cine C.	Kayirli	924	68 926	75	0.90
707	B. Menderes	Söka	15 026	182 340	212	0.81
812	Dalaman C.	Akköprü	4 481	349 240	78	0.73
801	Manavgat C.	Homa	1 418	216 923	147	0.69
802	Köprüçay	Beskonak	1 974	359 020	182	0.82
1708	Tarsus Ir.	Muhat Köp.	1 370	83 352	61	0.85
1818	Seyhan N.	Ustepe	14 015	2 673 438	191	0.81
1907	Asi N.	Demirköprü	16 170	340 437	21	0.93
2004	Ceyhan N.	Missis	19 095	5 460 916	286	0.87
		Total:	97 926	13 368 866		

* Overall average sediment yield for Mediterranean rivers is equal to 136 ton/year/km^2

The destruction of forest and overgrazing generated floods and sediment discharges creating new marshlands and barren lands. Continuing damage to forest trees led the Maqies and shrubland area to expand towards the forest area. Finally, damage to woodland is caused by wrong land use, forest fires, clearing cuttings to open up more forest land, overgrazing, and timber exploitation. Unprotected agriculture, inappropriate urbanisation, industrialisation, misuse of timberland and free use of pollutants have caused erosion, sedimentation, pollution and environmental deterioration. Coastal water ecosystems were disturbed as a result of frequent floods and sedimentation causing water pollution. The water-holding capacity of soil and infiltration rate of soil surface decreased, because of the removal of vegetation and organic matter of surface and compaction of surface. Degeneration of vegetation and erosion caused changes in the flow regime of rivers and river basins. The regularity of river flows changed so that sudden floods and peak flows are expected, creating more environmental problems. Extreme values of hydrologic observations became more dominant and sound hydraulic structure design and operation has become more difficult. The risk of water resources development has increased with the acceleration of erosion and sedimentation. Sediment discharges of Mediterranean rivers are very high in comparison with Europe and even Asia. In general, environmental problems reduced agricultural income, decreased the production value of land per unit area and increased the cost of flood and erosion control measures. Besides all of the major problems listed above, health problems have increased with the environmental disturbances of water ecosystems.

3. NATURAL CONDITIONS IN THE COASTAL ZONE OF TURKEY

3.1 Geological substratum

In Southern Turkey (the Mediterranean coast), the Palaezoic period of the permian sediments are mostly of marine origin (limestones and dolomites). In Western Turkey (the Aegean coast of the Mediterranean zone) minor outcrops of these triassic rocks of the Mesozoic period are found. In the Mediterranean region, the upper Cretaceous generally presents a facies of flysch, made up of a combination of sandy, schisty and calcareous sediments. The Taurus mountain ranges of the Mediterranean region consist of Palaezoic-Mesozoic and massive hard rocks. Soils developed over these geologic formations are highly susceptible to erosion. Recent studies have shown that most of the sediments came from the detachment and transportation of parent material of soil, not from the soil itself. In particular, loose and uncompact surface layers are subject to deep gully erosion, resulting in disturbances of the natural equilibrium and causing landslides and land collapses. In the most sensitive Mediterranean zones (erodible), land forming rocks are Cretaous, Neocene, Eocene, Palaeocene, Quaternary and volcanic ash and tuft formation.

South of the Gediz basin and North of Büyük Menderes are the Paleo-Quarternary deposits. These terrains, expanding between the area of Salihli and Turgutlu cities, are formed from Paleo-Neocene sandy, loomy, gravelly deposits. These soil deposits are easily scoured because of a lack of clay content. The soil conditions are responsible for the formation of the deep gulleys as a result of easy detachment and transportation of particles; this type of gulley erosion occurs frequently in this region of the Aegean zone.

The geology and lithology of Turkey are given in Annexes 3 and 4. These two maps are copied from the 1:300.000 scale original maps.

3.2 Topography

The Mediterranean coastal zones situated in the west of Turkey are called the Aegean region and in the south of Turkey the Mediterranean region. The mountain range lies parallel with the Mediterranean coastline located in the hinterland of the coastal plain. In contrast with the Mediterranean coast, the mountain ranges of the Aegean coast lie perpendicular to the Aegean Sea.

The Taurus mountain ranges rising to 3500 metres are divided between the Mugla and Antalya provinces and are called the Taurus and Anti-Taurus mountains. Being parallel to the Mediterranean coasts, the Taurus mountain slopes stops the influence of maritime climate from reaching central Anatolia. Therefore the south aspect of the Taurus mountains facing the coastline has a Mediterranean climate and the north aspect of Taurus mountains facing toward the central Anatolia has a continental climate. The mountain ranges of the West Aegean Sea coast are not high and are mainly of volcanic origin. Because of the vertical expansion of the mountain ranges in the Aegean region, the maritime climate has a strong influence. The land sloping features are: 19% steep slope and 17% very steep slope. The rough terrain conditions of Mediterranean zones as well as the Aegean cause the sensitive soil erosion conditions. The slope groups of Mediterranean provinces are shown in Table VI.

Rivers flowing towards the Mediterranean and Aegean Seas have not yet reached an equilibrium profile. The slope of Gediz river profile is 0.68%, Göksu river is 2.5%, Geyhun river 1% and Seyhan river is 0.60%. The coastal zone of the Mediterranean region starts from the Taurus mountain range with high plateaux stretching towards the foothills of the ranges. The lower plain land begins from the foothills of Taurus mountain up to the shores forming fertile lowland. Most parts of the Mediterranean region do not have land suitable for cultivation, apart from these lowlands. The sources of the rivers are the "Lake Region" in the western mountains, and the high mountains in the east. The rivers run toward the sea through lowlands, forming deltas, especially, Seyhan and Ceyhan, rivers of the Mediterranean Sea and Gediz, Küçük Menderes and Büyük Menderes rivers of the Aegean Sea. The Seyhan river has formed a 10 km long delta since ancient times. Consequently, a tremendous amount of sediment has been carried down and deposited by the river water course.

One other feature of the region shows carstic formation causing cavities and sinkholes. Because of calcereous parent material, erosion occurs easily and results in barren land and soil

As result of fluvial erosion cutting deeply into the land, its rugged and rough topography was formed. Most of this area is occupied by rough terrain and mountainous land. Massive land movement occurs where natural vegetation was removed from steep slopes. Land is shaped by the result of fluvial actions and the land surfaces will differ from the geologic appearance. In Annex 5, the geomorphology of Turkey is shown. The morphologic features of Turkey are seen in this map.

Table VI

Slope groups of Mediterranean provinces

Province Name	SLOPE GROUPS IN PERCENT (%)					
	Flat 0-2%	Mild 2-6%	Moderate 6-12%	Steep 12-20%	Very steep 20-30%	Abrupt slope 30% and more
Adana	401 639	99 224	128 520	123 696	220 934	503 746
Antalya	205 479	92 098	105 428	191 982	198 470	48 881
Aydin	148 159	44 009	65 158	103 814	219 649	157 403
Balikesir	102 277	91 718	159 291	258 516	294 275	391 320
Hatay	120 155	42 785	40 049	52 553	47 458	159 153
Içel	110 823	53 361	121 955	225 972	132 479	315 489
Izmir	208 857	79 268	112 961	201 856	292 056	208 306
Mugla	87 064	51 107	64 257	176 708	361 050	298 314
Percent					17%	19%
Total (ha):	1 384 507	553 570	797 619	1 335 097	1 766 371	2 082 612

3.3 Soil cover

Rough, hilly topography and deteriorated vegetation of Mediterranean zone considerably retard the soil development. The removed soil deposited somewhere along the coastal zone, is reddish in colour, poor in organic matter, and either neutral, slightly alcaline or acid in reaction. In this region soils called Terra-Rossa, overlay the calcereous rocks. Over the Gediz, Büyük and Küçük Menderes river basins and along the main stream beds of flooding zones alluvial soils developed. Over the high water tables lands saline-alluvial soils developed and over the depression lands, saline soils developed.

Soils of this region are generally shallow and poor. These poor lands are covered by short trees of shrublike vegetation called Gariq (Maques). The distribution of soil depths for the provinces of the Mediterranean zone is given in Table VII. As can be seen, 56% of the soil is very shallow, and 23% is shallow. Moreover, 41% of the land is covered with rockout crops as seen in Table VIII. Besides, 4% of the land has drainage problems due to high water tables along the coastal strip as seen in Table IX. Soils of the Mediterranean zone are generally sensitive to erosion. Calcic cambisols are largely confined to Spain, Portugal and Turkey, where they occur under Mediterranean climatic conditions. They are associated with hilly and mountainous topography and are mostly stony. In Turkey they are extensive in Western Anatolia and inland from the Aegean zone under continental Mediterranean conditions. They occur on hilly and mountainous topography which is devoted to cereals, to sheep, goats and cattle raising on poor pastures, and also fruit and forestry. Calcic cambisols are subject to severe moisture stress and slope is a major limitation, together with susceptibility to erosion.

Lithosol complexes occur in the major mountain land masses. The associated soils are varied and include Luvisols, Rendzinas, Podzols, Regosols and Rankers. Climatic types range from continental Mediterranean to taiga. In the Taurus mountain range and Eastern Anatolia, Lithosol zones are devoted to rough grazing of extensive livestock raising as the major use, with afforestation assuming a major role in some zones. Mean annual rainfall is 1000-2000 mm. Some vines, olives, maize and durum wheat crops are also cultivated. Afforestation is also important.

The Calcaric fluvisols are distributed widely throughout Europe and are very extensive in the Mediterranean zone of Turkey. They are highly important agricultural soils occurring on level topography along the major rivers. In the Aegean region of Turkey the Calcaric fluvisols are intensively cultivated with crops of figs and olives.

The Chromic luvisols occur most extensively in the subtropical Mediterranean to continental Mediterranean climate in Turkey, and are devoted to arable cropping and dairy production from pastures. The chromic luvisols, associated with hilly and mountainous terrain in Turkey, are stony. In southeast Anatolia in Turkey (under 400-800 mm rainfall), cereals, sheep, goat and cattle raising and some fruit and vine cultivation together with forestry constitute the land usage.

Table VII

Land distribution of Mediterranean province based on soil depth, in Ha

Province Name	Effective soil depth (cm) V. Shallow 0-20	Shallow 20-50	Moderately deep 50-90	Deep 90+	Other kind of land (ha)	Resident Area (ha)	Water surface area (ha)	Area of Province (ha)
Adana	. 812 792	264 694	110 707	427 545	79 355	14 239	15 935	1 725 267
Antalya	1 218 074	189 771	72 489	195 487	375 752	4 467	3 027	2 059 067
Aydin	327 656	212 320	55 328	189 779	5 600	7 930	8 302	806 915
Balikesir	735 745	481 188	69 998	118 589	11 881	17 154	18 250	1 452 814
Hatay	148 956	198 959	41 347	135 146	3 018	6 239	6 596	540 261
Içel	1 063 918	265 784	44 351	120 592	79 533	9 327	1 754	1 585 259
Izmir	413 312	448 887	44 020	262 219	12 132	19 983	1 338	1 201 981
Mugla	659 247	371 328	41 186	104 444	57 962	6 533	9 750	1 250 400
Percent	56%	23%						
Total (ha):	5 379 700	2 432 931	479 426	1 553 801	625 233	85 872	64 952	10 621 964

Table VIII

Rockiness problem area of Mediterranean zone (ha)

Province Name	Arable land (ha) Class II-III-IV	Non-arable land Class V-VI-VII	Total land (ha)
Adana	23 989	538 514	562 503
Antalya	24 581	387 118	411 699
Aydin	52 168	378 337	430 505
Balikesir	4 388	660 036	664 424
Hatay	21 798	177 689	199 487
Içel	43 229	611 075	654 304
Izmir	41 526	579 797	621 323
Mugla	26 445	804 247	830 692
Percent	2%	39%	
Total:	238 124	4 136 813	4 374 937

In the Aegean and Marmara zones of Orthic Luvisols, arable cropping and fruit production are important enterprises in the more favourable soil areas, with forestry and rough grazing comprising the remaining uses. The Pellic Vertisols are fine textured and occur on level topography. They also occur under continental Mediterranean conditions in Turkey.

In summary, the soils are mainly Calcic and Eutric Cambisols, Chromic Luvisols and Xerosols, which are very often stony or lithic in character and associated with hilly and mountainous topography. They are highly susceptible to erosion. Annexes 6 and 7 show the soil map and soil zones map of Turkey respectively.

3.4. Vegetal cover

The Mediterranean region lost its climax vegetation as a result of denudation, destruction and misuse. Forest communities (natural units of forest vegetation) arise, develop, and mature under the influence of the site factors and the reaction of vegetation upon them. The entire process of community development is expressed in its forest succession, the final stage of which is called the climax stage. The type of vegetation, community, of climax stage is named as the climax of that region; it is a good indicator of environmental protection. In the Mediterranean region succession has been disturbed and climax vegetation has been changed and succession has been set back. If climax vegetation is destroyed, the succeeding communities may pass through several stages until it may again reach the climax stage:

- moss meadow
- aster-firewood meadow
- hairgrass-sedge meadow
- willow-birch thicket
- aspen forest
- original forest tree (climax)

Table IX

Wetness problem area of Mediterranean zone in Ha

Province Name	Inadequate drainage		Poor drainage		Bad drainage		Excess drainage		Total (ha)	
	Land class II-III-IV	V-VI-VII	Land class II-III-IV	V-VI-VII	Land class II-III-IV	V-VI-VII	Land class II-III-IV	V-VI-VII	Land class II-III-IV	V-VI-VII
Adana	89 933	–	28 149	32 485	–	14 684	–	–	118 082	47 169
Antalya	27 776	–	34 041	1 382	–	3 726	–	144	61 817	5 252
Balikesir	27 776	–	6 571	897	–	3 200	–	–	34 347	4 097
Hatay	34 348	–	6 648	1 083	–	–	–	–	40 996	1 083
Içel	1 376	–	–	–	–	–	–	–	1 376	–
Izmir	58 344	5 585	6 196	12 251	–	2 944	–	477	64 540	21 257
Mugla	25 559	–	2 422	5 683	–	5 535	3 652	3 833	31 633	14 851
Percent									3%	09%
Total:	265 112	5 585	84 027	53 781	–	30 089	3 652	4 454	352 791	93 709

It may be said that, not only the Mediterranean region, but also other regions of Turkey have lost most of their climax. The vegetation communities of Turkey can be called secondary communities. The map shows the vegetation types of Turkey and Mediterranean regions (See Annex b). Xerofit forest species and Chapparal species are widely spread along the coastal zone of the Mediterranean region. Pinus brucia forest stretches up to 1000 metres altitude at the climax stage. Above 1000 metres high, Pinus nigra and Cedrus libani forest predominate. Destruction of forest trees changes the forest vegetation into Maqiues and sparse, scanty shrub. Forest trees have been destroyed by fire, illegal cutting and opening, misusing and overgrazing of forest. Vegetative formation of the Mediterranean region differs in the different climatic and topographic features. Forest, shrub and grass formations are the main types of vegetation. Shrub formation lies from sea level to 500-600 metres. Shrub formation includes low trees and a few pine trees. The Taurus mountain range is covered by coniferous forest, especially Cedrus libani (Cedar). Misuse of forest land started since the Roman Empire and has continued up to the present, resulting in degraded forest, severe erosion sedimentation problems.

The forest cover of Turkey and its Mediterranean region is shown on the map as Annex 9. The shrub formations which cover most parts of the Mediterranean region are stabilised because of the destruction of the natural timberlands.

The forests of the Mediterranean region cover an area of 4.747.069 ha of which 1.805.304 ha is normal forest and 2.941.765 ha is degraded forest. Forest cover along the Mediterranean coast is about 3.190.137 ha and behind the mountain parallel to the coast is about 1.555.521 ha. Forest cover and the state of forest in the Mediterranean zone are given in Table X.

As a result of inappropriate land use, forest fires, overgrazing and the destruction of natural vegetation, the forest cover of Turkey has largely degenerated. Most parts of the forest area have undergone various erosion hazards. As a matter of fact the erosion is continuous in the degenerated forest areas.

The vegetation formation of Turkey in Annex 8, is useful for comparison purposes. Shrub or Chapparal formation of the Mediterranean region may be seen between 800 to 1000 metres above sea level. Quercus coccifera, Pistacia lentiscus, Laurus nobilis, Myrtus communis and Philiyrea latifolia are the main species of this formation. Between 800 to 2000 metres above sea level, forest tree formation continues up to Alpine and Subalpine zones: main species of this formation are Pinus brucia, Abies clicia, Pinus nigra, Cedrus libani, Quercus libani, Juniperus ornus, Acer platanoides, Populus tremula, Salix alba, Ulmus glabra and Pistacia terebinthus. Above 2700 metres, grass vegetation of the subalpine zone covers the area. The main species are Anchontholimon androsaceum, Anchontholimon Kotsehyi, Anchontholimon vernustum, Anchontholimon pinardi, Astragalus angustifolius, Prunus prostrata and Berberis crataegina. Crepis pinnattida and Crepis tauricola extend up to a height of 3300 metres.

Table X

Forest state of the Mediterranean zone based on provinces in hectares (ha)

Province	Self-sown (natural) forest (ha)			Sprout forest (ha)			Whole area occupied (ha)		
Name	Good	Degraded	Total	Good	Degraded	Total	Forest	Bare land	Overall Total
Adana	227 824	267 565	545 389	19 850	160 668	180 518	725 907	1 030 293	1 756 200
Antalya	496 611	260 261	756 872	19 142	451 441	470 583	1 227 455	854 045	2 081 500
Aydin	82 454	79 905	162 359	15 506	170 054	185 560	347 919	439 919	787 000
Balikesir	253 334	116 910	370 244	39 728	331 638	371 366	741 610	703 990	1 445 600
Hatay	67 201	55 483	122 684	20 920	46 804	67 724	190 408	366 592	557 700
Içel	285 786	338 922	624 708	377	165 034	165 411	790 119	754 681	1 544 800
Izmir	115 158	97 434	212 592	22 323	271 915	294 238	506 830	719 470	1 226 300
Muğla	339 306	257 186	596 492	11 258	223 742	235 000	831 492	418 908	1 250 400
Total (ha)	1 473 666				1 821 290		4 363 740		10 648 800

NOTE: Seventy-five percent (75%) of forest land has been degenerated in the Mediterranean zone as well as in Turkey.

3.5 Climate

The Mediterranean coastal zone has a climate of hot summers and mild, rainy winters. The climatic index map of droughts is shown in Annex 10. Among the climatic elements, rain and its intensity are the most important factors affecting water erosion in the Mediterranean zone. Therefore these factors should be given more emphasis than the other factors in the erosion process. The Mediterranean zone stretching along the Aegean seashore in the west of Turkey is called the Aegean region. This region has an orography which favours precipitable clouds which bring the rains. The average annual precipitation distribution and climatic regions of Turkey are shown on the maps as Annex 11 and Annex 12.

Precipitation falls in the west are usually as a result of low pressure or depression. The hinterland of the coastal zone receives the convective precipitations. The coastal highlands receive an orographic type of precipitation. The southern part is also under the effects of a low pressure centre. The high mountains rising behind the coast receive mostly thunderstorm type of precipitation falling as showers. Antalya and Iskenderun, Mediterranean sea ports, usually get rain of a similar kind. One hour duration maximum rainfall frequency curves are given in Annex 13 for 5, 10, 25, 50 and 100 years return period for the Mediterranean region and Turkey. Erosivity of rainfall is also given for this region (see Annex 14). Thundershowers are the most erosive rainfalls causing erosion in the Mediterranean region.

The erosive potential of the rainfall is very high especially along the coastal strip. As a general rule, the Mediterranean region has the highest erosive potential and it varies according to month, vegetation and parent material. Winter, late spring and early summer are the erosive seasons. Although the erosive potential is high in the Mediterranean region, erosion does not occur where the parent material is composed of hard limestone. In this region the prevailing Mediterranean climate gives an average temperature in Winter months of about 10 ^{o}C. It almost never snows and there is no frost. The annual average rainfall in the mountainous part of this region is 1000 mm and 600 mm in the plains along the coastal zone. There are nine provinces which fall into the coastal zone of the Mediterranean and Aegean regions, namely, Hatay, Adana, Içel, Antalya, Mugla, Aydin, Izmir, Manisa and Canakkale. A summary of their climatic characteristics is shown in Table XI.

3.6 Land uses

In the Mediterranean region, the major groups of land uses are:

- agriculture
- forestry
- grazing
- horticulture

Mediterranean and Aegean zones could be divided into six watersheds or drainage basins as follows:

(i) Eastern Mediterranean drainage basin
(ii) Antalya drainage basin
(iii) Western Mediterranean drainage basin
(iv) *Gediz river basin*
(v) *Küçük Menderes river basin*
(vi) *Büyük Menderes river basin*

Table XII shows the division of basins and land use.

Land capability classifications were given in the preceding chapter (Table IV) and suitability for agricultural use of the Mediterranean region is also shown in Table XII. In this given zone, most of the land requires soil conservation measures. Land of the Mediterranean region is sensitive to soil erosion. If land is used according to its capability and with necessary measures, erosion problems will be greatly reduced. *Therefore,* land capability classification and land use zoning are very important steps in this process.

Present land use in Turkey is as follows: Cultivated land covers 35.6% of Turkey, totalling 27.699.003 ha; range and pasture land covers 28% with an area of 21.170.196 ha; high and low quality forest area covers 26% of total land with an area of 20.468.463 ha; maquies and shrubs are 3.298.267 ha; urban areas are 569.400 ha; others (marshlands, sand dunes) are 3.212.175 ha and lakes are 1.102.396 ha.

Table XI

Climatic properties of the Mediterranean provinces

Province name	Mean annual temperature (°C)	Maximum temperature per year (°C)	Minimum temperature per year (°C)	Mean annual precipitation (mm)	Average relative humidity (%)
Hatay	18.2	44.0	-14.6	1157.0	69
Adana	18.7	45.6	- 7.1	900.0	65
Içel	18.6	40.0	- 6.6	600.0	72
Antalya	18.7	44.6	- 7.1	1070.0	64
Muğla	17.2	40.0	- 7.4	1000.0	65
Denizli	17.3	42.0	-10.0	630.0	60
Aydin	17.7	43.0	-11.0	676.0	63
Izmir	16.3	43.0	- 8.4	740.0	66
Manisa	17.2	44.0	- 8.0	700.00	62
Balikesır	16.2	42.0	- 8.0	640.0	60
Canakkale	16.8	42.0	- 8.3	610.0	64

Table XII

Existing land use and suitability of the Mediterranean zone in Ha

Province name	Cultivated land (ha)					Range-Meadow land		Forest-shrub land		Other kind of land					Water surface (ha)
	Dry farming														
	With fallow	Without fallow	Irrigated farming	Orchard vines	Special crops	Meadow	Range	Forest	Shrub	Resident area	Reed bed marsh	Riverbed	Sand dunes	Bare rock	
Adana	102 823	447 738	111 754	12 194	-	-	84 508	649 133	207 588	14 239	-	4 177	9 591	65 587	15 93
Antalya	203 384	83 590	94 439	2 442	8 642	7 836	108 581	736 191	425 716	4 467	499	7 901	4 893	362 459	3 02
Aydin	13 320	38 234	120 886	17 572	144 694	586	53 112	243 714	152 965	7 930	-	2 560	24	3 016	8 30
Balikesir	7 851	455 335	46 476	4 579	60 778	1 008	153 238	475 289	200 966	17 154	3 200	5 948	588	2 145	18 28
Hatay	23 329	124 211	75 502	15 538	28 224	-	49 673	148 600	69 331	6 239	583	884	1 089	462	6 59
Içel	167 554	77 512	101 076	39 251	3 386	140	219 681	713 240	172 805	9 327	760	914	2 387	75 472	1 75
Izmir	21 415	127 203	101 357	34 020	108 490	105	191 732	250 244	333 872	19 983	-	2 191	261	9 680	1 33
Mugla	30 737	78 593	56 406	4 683	40 969	758	47 918	681 480	234 611	6 533	17	4 220	1 775	51 950	9 75
Total:	575 413	1432 416	707 896	130 279	295 183	10 433	908 443	3897 891	5787 854	85 872	5 059	28 795	20 606	570 771	64 99
Percent:						8.7%		37%	54%						

3.7 Relevant socio-economic conditions in the region

The population of the region is increasing rapidly, most working in agriculture, livestock (grazing) and forestry, and a few are occupied in apiculture, horticulture and viniculture. Incomes of local people are falling, and pressure on forest land is increasing. Agricultural and grasslands are expanding at the expense of forest land, with forest fires, converting and opening of forest lands and overgrazing natural by-products. The impact of the people on forest and cultivated land causes erosion and sedimentation, resulting in a day-to-day loss of income. Incorrect land use destroys the forest and the resulting sedimentation destroys the agricultural land. Although there is a short-term increase in income as a result of the recultivation of forest land, the result after a few years is the permanent deterioration of forest land.

To solve this problem permanently a new source of income for the people of this region should be found, in order to relieve pressure on the forest land. Only by guiding the people towards new sources of income, can a real solution to the problem be found, otherwise it could become a permanent one which could lead to other, more serious problems.

In conclusion, the land use of this region should be severely restricted based on land capability classification. Intensity of livestock, forestry and agricultural activities should be determined and based on the safe carrying capacity of the land. Whenever the production capacity of the region does not satisfy the needs and demands of the people, excess people should be removed from traditional activities and directed towards new sources of income. The Government should support the farmers by means of soil conservation methods, and all environmental control activities should be subsidised. Environmental control projects and new investments should be initiated and financed by the Government for the people of this region, in order to protect the environment and natural resources for the present and future generations. Legislative measures, rules and regulations have never solved this kind of problem without sound measures to ensure enough income for the people.

4. CONCEPT AND METHODOLOGY OF THE EROSION MAP

4.1 Basic concept and main purposes of the soil erosion map drawing in Turkey

The reason why the erosion map was prepared in Turkey was to control the erosion of agricultural and forest soils, and to plan the development of the soil and water resources in accordance with reconnaissance and feasibility levels. In other words, the purpose of this was to initiate general planning of natural resources without erosion, wastage and deterioration, and to create a very important tool for the planner and designer. Moreover, the idea was to announce the present state of soil erosion problems in Turkey and to show the way for soil conservation methods and to bring about the first stage of the planning tool. These maps will be the first approximation of the qualitative evaluation of the soil erosion and the initial stage of a more detailed study of soil and soil erosion. As a result of further surveying, important features and more detailed properties of soil and erosion will be traced on the soil erosion maps. To plan, design and complete any environmental control and development project, erosion maps are basic, handy and necessary tools. Although the maps prepared by the Department of Soil-Water (TOPRAKSU) do not show all the features of soil and soil erosion, they suffice for the planning of projects at a general level.

The basic concept and main purpose of the soil map drawing in Turkey were: (i) to prove the danger of the state of erosion; (ii) to show the general erosion control measures of forest and agricultural land; (iii) to start erosion control measures on forest and agricultural land; (iv) to get to know recent land use types; (v) to direct the potential land use, based on land capability classes; (vi) to make the land capability classification; (vii) to initiate the utilisation of renewable resources based on realistic planning; (viii) to provide a valuable tool for planners; (ix) to provide a basis for future detailed studies and surveys of soil; (x) to gain enough experience and to train the experts to prepare future detailed erosion maps to be used in the design and application of the project.

To summarise, the general concept of the erosion maps was to provide a most important tool for designers and field engineers, in order that the natural resources could be utilised to the optimum level and the environment protected without causing harm to future generations.

4.2 Selection of the scale according to map use

General Soil Surveys of Turkey (GSST) were carried out during the period 1965-1971. The original soil survey was done on 1:25000 scale topographic maps by 70 soil scientists. Analysis of field work data was completed in 1974. The erosion map information was compiled from provincial soil maps on a 1:100.000 scale. The map preparation, and the interpretation of soil maps, was carried out by Ibrahim and Co-workers from the General Directorate of Rural Affairs (TOPRAKSU). The results of the soil survey were published in two series: (1) Province soil reports and maps of 1:100.000 scale, and (2) River basin soil reports and maps of 1:200.000 scale.

In the survey 1:25.000 scale topographic maps were used as base maps, but the maps were not used to their full capacity since this was the first approximation or it was the general level survey with an accuracy of 70%.

The degree of erosion shown on the soil maps makes large boundaries when it is shown as a single factor on the interpreted maps. For this reason, a map much smaller in scale than the 1:100.000 soil maps could be sufficient as a final document. Therefore, 1:1.000.000 scale was selected for the erosion map. This scale was adequate enough to show the erosion boundaries which exist on soil maps up to 90% accuracy. This scale was also very convenient for use as a wall map in schools, institutes and at public meetings, etc.

4.3 *Definition of cartographic units used in the map*

Simple erosion degrees are shown on the map. Four degrees are separated. This separation is also made in soil maps of 1:100.000 scale, and adapted from USDA soil conservation service standards.

The erosion degrees which are used as mapping units are explained below:

OY - Improperly drained bottomland; erosion is not a problem

o - Well drained bottom land; erosion is not a problem

1 - Slight erosion; less than 25% of the top soil is gone

2 - Moderate erosion; 25-27% of the top soil is gone

3 - Severe erosion; more than 75% of the top soil but less than 50% of sub-soil is gone

4 - Very severe; the top soil and more than 50% of the sub-soil is gone

CK - Rock surfaces and debris

R - Wind erosion
R1 slight
R2 moderate
R3 severe
R4 very severe

SK - Sand dunes

Soil, slope and vegetative characteristics are not shown on the map, but they mostly accord with the degrees of erosion.

Three main physiographic units and some 20 great soil groups are separated as shown in Table XIII. Upland soils were shown based on slope and depth combination numbers as mapping units. The stoniness and degree of erosion were added to this number.

The following mapping unit was formed:

B 7t.2 where:
B is for brown soil great soil group
7 is for gently sloping shallow soils
t is for stoniness
2 is for erosion degree: moderate

The mapping key of the survey is given in tabular form. In Table XIV, slope, depth classes and other differentiations are shown. For the alluvial soils, after the great soil group letter, drainage and texture combination numbers take place. If there is salinity and alkalinity, related small letter symbols are added to combination numbers.

Hence the following mapping unit is formed:

A 5 h where:
A is for alluvial great soil group
5 is for imperfectly drained, medium textured soil
h is for slight salinity

For other bottomland soils similar mapping units are formed.

Colluvial soils are grouped according to their depth, slope and textures. Erosion degree and stoniness are added to mapping units.

Colluvial mapping units are as follows:

K 10t.2 where:
K is for colluvial
10 is for gently sloping, deep, fine textured soil
t is for stoniness
2 is for moderate erosion

Table XIII

Genetic soil classes

Physiographic unit	Main properties	Great soil groups and symbols
Bottomland	Soils on recently deposited alluvium, level, depth, soil, wetness, salinity and alkalinity may be a problem	Alluvial - A Hydromorphic - H Organic - C Saline - C
Footslopes	Recently deposited colluvial soils with mixed texture	Colluvial - K
Uplands	Soils formed on residual material areas out by watercourses, well drained, depth and erosion limitation exist, genetical horizonation exists	Brown - B Reddish brown - F Chestnut - C Red chestnut - D Non calcic brown - U Brown forest - M Acid brown forest - N Podsolic - P,G Alpine meadow - Y Rendxinas - R Red Mediterranean - T Reddish brown - E Mediterranean vertisols - V Basaltic vertisols - X Regosols - L

4.4 Selection of surveying parameters

In the soil surveys from which this erosion map is interpreted, the main soil group, slope and vegetation and/or use characteristics are delineated. They are shown below:

- genetic soil group
- soil depth
- slope group
- stoniness
- degree of erosion
- land use or natural cover.

For bottomland soils, the following are added to mapping units:

- texture
- drainage
- salinity.

The soil depth, slope, etc. classes which are used in the soil survey are explained in detail, separately, in section (4.3).

Table XIV

Key for mapping units of TETH (GSST) surveys

UPLAND SOILS

Symbol	Great soil group	Slope-depth combination: Slope %	Depth (cm) 90+	90-50	50-20	20-	Erosion
							1.None-slight
B	Brown	0-2	1	2	3	4	2.Moderate
F	Reddish brown	2-6	5	6	7	8	3.Severe
U	Non calcic brown	6-12	9	10	11	12	4.Very severe
M	Brown forest	12-20	13	14	15	16	R Wind erosion
N	Acid brown forest	20-30	17	18	19	20	t Stoniness
P,G	Podsolic						
T	Reddish brown M.		21	22	23	24	
V,X,R	Others	30+	Lithosolic			25	

COLLUVIAL SOILS

K COLLUVIAL

Slope-depth-texture combination

Slope %	Texture	Depth (cm) 90+	90-50	50-20	20-	Erosion
0-2	Fine	1	2	3		The same as above
	Medium	4	5	6		
	Coarse	7	8	9		t Stoniness
2-6	Fine	10	11	12		y Imperfectly drained
	Medium	13	14	15		
	Coarse	16	17	18		
6-12	Fine	19	20	21		
	Medium	22	23	24		
	Coarse	25	26	27		
12+	-	28	29	30	31	

BOTTOMLAND SOILS

A ALLUVIAL

Drainage — Texture combination

Drainage	Texture: Fine	Medium	Coarse	V. Coarse
Good	1	2	3	
Imperfect	4	5	6	
Poor	7	8	9	
Excessive				10

H	HYDRO-MORPHIC	Very poorly drained
O	ORGANIC	Om.Muck.Op: Peak or: Mixed
C	SALINE	Salinity-Texture combination numbers 1-9

LAND TYPES	Example	
CK ROCK SURFACES	B7+2	B Brown soils
IY RIVER WASHES	(Upland soils)	7 sLOPE 2-6%, depth 50-20 cm
SK DUNES		t Stony
		2 Moderate erosion

4.5 Necessary cartographic bases

Since the base work of the general soil survey of Turkey was already complete, the erosion mapwork was built on the ready material. The results were mounted and traced on a 1:1.000.000 scale standard topographic map of Turkey with fine cartographic processes.

4.6 Method of field surveying

The original soil survey was done on 1:25.000 scale topographic maps, by checking soil, slope and vegetation characteristics in the field every 0.5-1.5 km. Field samples were taken for laboratory analysis. Representative soil profiles were dug and sampled for laboratory evaluation. Important features of the surveyed land were recorded and marked on the map used during the survey. Topographic detail that exists on those high standard maps was also used in delineating soil boundaries. These 1:1.000.000 scale maps are published by the compilation of field maps.

Working on these soil maps, soil mapping units were unified to form erosion map units. So instead of hundreds of mapping units of soil maps, some 12 mapping units were formed for the erosion map. Other soil characteristics were excluded from the legend of the erosion map. (see section 4.2).

4.7 Method of data processing and creation of cartographic units

Erosion unit boundaries were drawn on soil maps with thick dark oil pens. These maps were then reduced 10 times by photomechanical methods. Those reduced films were coincided on 1:1.000.000 original topographic map, so that the accuracy of the scale was controlled.

At the end, the erosion map of Turkey was formed (In section 2.5, processing of the maps has been explained).

4.8 Use of aerial photography and teledetection

Since the standard 1:25.000 scale topographic maps, and 1:100.000 scale soil maps were made available nationwide, and as the level of the soil survey did not necessitate further base map detail, no other means were used in the work. However, for further detail surveying, aerial photography and teledetection could be used.

4.9 Technical standards of the map

The final erosion map is as accurate as the original base map of 1:1.000.000 scale cartographically, and it is also almost as accurate as the original soil maps. Perhaps some 10% detail of the 1:100.000 scale soil maps is missing on the erosion map.

The scale was reduced 10 times, but also the mapping units of soil maps were decreased to form this simple, understandable erosion map.

The reliability of the soil maps from which the erosion map was derived, was some 70% because of the general level of the soil survey. In other words, accuracy of the erosion map is about 60-65%.

4.10 Map interpretation norms

The erosion map is simple and easily understood. In order to make further interpretations, soil, slope, and vegetation maps should be prepared from the same origin. In this simplified form the map can be understood by the public, by school students and administrators.

5. EVALUATION OF ACHIEVED RESULTS

5.1 Critical evaluation of the elaborated map

The map might have been prepared in more detail so that more sub-units could be separated according to land use, soil or slope within the mapping units-erosion degrees. This would, however, make the interpretation of the map difficult for users who are not familiar with this type of specialisation.

Collected field data are adequate enough to prepare better erosion and soil maps than those which exist at present. For example, land classes based on degree of erosion can be reclassified based on land uses so that the same erosion class of land will be shown in different land uses according to soil types. Consequently, there could be more alternative maps showing sub-classes and they could be used for different purposes. Land capability classes and erosion classes are determined, based on degrees of limitations but there are different kinds of limitations. Different types of limitations will dictate different classes of land and they will show various degrees of erosion, that is to say, the same capability of erosion class of land may have the same degree of erosion because of the different type of limitations, resulting in sub-classes. For instance two pieces of land will be designated as Class-II and Class-III due to erosion. Now here the kind of limitation is the same for both classes, which means that both classes have identical sub-classes, but the degree of erosion differs for Class-II and Class-III. Therefore for Class-II_e and Class-III_e sub-classes in which "e" stands for erosion, and II^e, II stands for class number, samples can be increased so that the same classes of land may result from different kind of limitations but same degrees, that is, two Class-III lands has different sub-classes, meaning their limitations differ from each other. For instance, Class-III_t and Class-III_w lands have limitations of topography and wetness with same degree respectively.

As a result, there could be a number of combinations from kinds of degrees of limitation. Each combination could be interpreted on the map separately, resulting in different kinds of soil and erosion maps equal to the number of combinations. Moreover, another parameter of soil type could be inserted among the kind and degree of limitations which would have further increased the combination number of maps. If all these combinations were shown or designated on the map or maps, better maps could have been prepared with existing field data.

In conclusion, a series and a family of maps could be drawn by classes and sub-classes of land and erosion with each combination of kind, degree and type separately. These separate maps may have served for different purposes on the general planning level. Existing erosion and soil maps are good enough for general planning purposes. Master plans could be prepared by means of these existing maps. However existing maps do not serve for the purpose of design and applied planning. For the application of any project in the field

requires more detailed small scale maps. New field works and more detailed soil survey are necessary to make a required map for an applied project. Existing maps can be used as guide for new surveying. The aim of new surveying should be to prepare 1:25.000 soil and erosion maps which could be used for field application of erosion control project and soil water development project. Whole surveys will be repeated in a more precise and detailed study. Data collection and observations of soil on the fields will be made more systematically in short distances and more frequently than before, based on soil survey procedures of random systems. At every change of slope, topography, soil type and other features should be sampled and observed systematically and field observations and findings will be recorded for further analyses. Soil and other necessary samples will be taken from the observation sites and they will be analysed in the laboratory for the bases of interpretation. Since the organisation has already been established for the reconnaissance surveying and its members have gained some expertise, the same organisation and members could be used after improving them for the detail surveying.

5.2 Limits of reliability and usability of the map

The map has a 60-65% accuracy and this is sufficient for map users of schools, administrators, etc. For other purposes, further detailed information and more accuracy are needed. Soil maps can be used for illustrations according to different kinds of interpretation.

If more details were desired, further detailed soil surveys could be carried out. For general planning or for the master plan of a project, these maps are good enough to use as the bases for soil conservation methods. Also, these maps will serve to educate the school population so that a new group would be in favour of erosion control. Another use of these maps is in the field of land management. Land can be divided into management units for similar properties, and erosion control measures.

5.3 Appraisal of experience in map use

It is better to prepare different maps with new interpretations and deriving and compiling more information from the collected data of the surveys. At the same time better use could be made of the erosion map. With the help of these maps, people in this field were able to announce the fact of erosion all over Turkey. Now most people know that erosion has been a big and important environmental problem to be solved as soon as possible.

These maps were distributed to all governmental and military offices, so that they would give maximum publicity. Fortunately public opinion has taken shape since the erosion maps were printed and circulated. Most of the institutions have been directed toward the erosion problem through erosion maps. Interested governmental departments were united on watershed management programme after the publicity. Different disciplines accepted that the erosion problem was unique, and accepted that it requires multi-disciplinary solutions. Forestry and agricultural staff understood simultaneously and mutually that they should have done something about erosion control. It was well understood that before it is too late, erosion must be reduced, stopped, and controlled with the help of all establishments. After enough publicity, the President's Office and General Staff of Army's Office showed interest in these maps and problems and, as a result, they asked for a briefing at Headquarters. This means that the erosion problem became well known throughout all echelons of Turkish society. That was one of the objectives of the survey.

5.4 Potential and actual map users

Potential users of these maps are administrative people at all levels, academic staff for educational aids, members of organisations for the purpose of training technicians. Besides its national use, international experts and international staff would also use them. Universities, colleges and military people could also use them.

Actual users are agronomists, foresters, engineers and technicians, as well as school teachers, trainers and other similar people in provincial and country. For the purpose of the feasibility study, high level planners will be the actual users, and they will train other technicians who would be the potential engineers to start new detailed soil surveys for future maps. Officials who deal with land uses could determine the land for cultivation, land for forestry, land for grazing, land for industrial location, land for military location and land for other uses from the existing surveying data and resulting maps. These existing maps could be the basis for potential users who would derive the criteria of land allocation and land use.

5.5 Map as the basis for the planning of environmental protection

The map may be used for the environmental protection planning purposes at national level. This erosion map of 1:1.000.000 scale is not sufficient for local projects. For the purpose of regional and local level projects, soil maps of at least 1:100.000 scale should be used.

General problem areas from the environmental point of view can be traced through these maps. Types of environmental problems and location of problem sites could be indicated and marked on the map. Existing reports and maps are adequate to identify the problem types and their areas.

Soil maps of 1:100.000 scale are quite adequate for regional environmental planning. Erosion maps of 1:100.000 scale are sufficient for national and international level planning. For the sophisticated applied project of environmental planning more detailed maps of 1:10.000 or 1:25.000 scale are required. For the area of relatively smooth terrain, maps of 1:10.000 scale can show enough detail for required purposes. For the area of relatively rough terrain, the maps of 1:25.000 scale may show sufficient detail for the applied project.

Based on existing maps, the feasibility study can be carried out and related reports prepared. The design and final report of environmental planning will be proceeded with after the feasibility study.

These maps have been further used in the general soil management plan of Turkey. A soil management plan is one of the essential tools for the control of erosion and to protect the environment while the soils are used for the purpose of production. Production and protection can not be achieved simultaneously unless soil management units are prepared. Since these maps are the basis for soil management units it could be said that they are also the basis for planning of environmental protection.

The general soil management plan of Turkey was prepared, based on provincial soil maps of 1:100.000 scale over the years of 1980 to 1986. The soils of Turkey are grouped and divided into 79 management units. The units were determined based on the properties of soils and limitations of soil use. Each unit has its own land use type and soil conservation method. Further

development plan and environmental protection plan can be initiated and can be done at the general level based on this soil management plan. In preceding sections attention has been directed to the detailed surveying and detailed map drawing for the purpose of applied projects. This work of soil management plan was mainly technical, but non-technical and social aspects of the problems were also taken into consideration and solutions were proposed in this general report. Proposed implementation plan of 50 years was also given to put the plan into action.

Erosion degrees from 0 to 4 and their areal distribution and percentages were given as follows:

Degree of erosion	Area hectares	Percent of Turkey
0 None	5 166 627	% 6.64
1 Slight	5 611 892	7.22
2 Moderate	15 592 750	20.04
3 Severe	28 334 933	36.42
4 Very severe	17 366 463	22.32
CK Rocky surfaces	2 930 933	3.77
Wind erosion	506 309	0.65

As seen above, 83% of Turkey suffers from moderate or worse erosion effects. In the report, the following erosion control measures are suggested:

(i) wise land use according to land capability classes;

(ii) cost-free cultural and vegetative measures; and

(iii) expensive physical, technical, mechanical and engineering measures.

All these erosion control measures above were proposed for each soil management unit. These measures are mainly contour farming, strip cropping, ripping, mulch farming, terracing, stone and rockout crops clearing and piling on contour, gully control measures etc. Proposed measures have also been evaluated economically, following the area of land to be controlled and measures to be taken:

(i) measures for dry farming land - 15 104 717 ha
(ii) measures for range and bush - 15 481 760 ha
(iii) wind erosion control and others - 485 990 ha
(iv) cost-free measures (contour farming) - 13 611 865 ha.

Estimated costs of these measures are:

(a) Total cost of field measures - 5×10^{12} T.L.
(b) Cost of line measures and forestry - 5×10^{12} T.L.

Total cost - 10×10^{12} T.L.

Total investment need (1985) - 13.3×10^{12} T.L.

Total investment need in US dollars - \$ 26.6×10^9

Non-technical or regulative measures are necessary to facilitate and to make the technical measures possible. The following regulative proposed measures and suggestions are given:

1. The change of misused Class VI and VII cultivated land to range and to forest land by owners;

2. The rearrangement of ownership boundaries according to contour lines;

3. The prevention of the uncontrolled grazing and free herding;

4. Subsidies to farmers who have accepted the control measures and renting them farming machinery;

5. Guiding farmers to take measures on Class II, III and IV lands;

6. Legislature to authorise the new organisation to take charge of the works above.

The new organisation to be established will employ 7,140 staff to implement the new soil surveying and proposed plan. The proposals can be carried out over 50 years plus 15 years of preparation time. According to this plan, the annual area of work will be 721 000 hectares with the cost of 266.4×10^9 T.L. To implement this proposal another detailed plan should take place. To make a detailed plan more information and data are necessary. These data will be obtained from a new soil survey in the light of experience up to now. The new detailed plan will be based on this new future soil surveying work.

5.6 Institutions, organisations and expertise

These are the requirements for a successful use of the map. Existing maps are very simple to understand. One of the objectives was to generate enough publicity on the soil erosion problem. Firstly, erosion should be considered as a national problem. Secondly, it should be accepted that erosion has to be controlled. Thirdly, it should be known that effective erosion control needs more data and surveying. Fourthly, erosion control requires new organisation and institutions with skilled people. Then more detailed soil surveys will be done and new maps will be developed with new interpretations so that more accurate and applied environmental plannings can be prepared.

Moreover, existing institutions and organisations should be coordinated, reorganised, rearranged and reordered for the purpose of these future tasks. Besides the new organisations and reorganisations, new staff should be trained for given purposes and required skills should be obtained. Different local and regional people will have various skills which perhaps can be utilised. These skilled staff will be in charge of the project on a national and an international basis. All organisations and institutions with their skilled people should be directed toward the applied works. For the applied projects and plannings, all necessary documents, data, information, maps and other related materials should be obtained, developed and prepared by these people.

5.7 Economic analysis of the overall project

Land survey and field analysis were accomplished by the official staff of the Central Soil Conservation Units, General Directorate of Rural Affairs. After the completion of field works, laboratory analysis and office works were also carried out by almost the same staff. As a result of data analysis and interpretation, maps were prepared by the methods as mentioned in preceding chapters. Since all the staff in charge of the works were full-time employees of the government and they worked during office hours, this project can be said to have cost nothing extra except for printing of maps and their salaries. It cost 7.5 x 10^6 T.L. for the printing of 50,000 maps, but to control erosion and to take measures costs a lot. The cost development of soil management units with their land use practices and their erosion control measures were estimated as 7.198 x 10^9 T.L. between the years 1957 to 1985. Annual investment of the above project requires 266 x 10^9 T.L.

6. APPLICABILITY OF RESULTS TO A BROADER MEDITERRANEAN AREA

6.1 Project's importance for combating erosion in Mediterranean coastal zones

Applicability of methods, materials and procedures used for soil surveying of Turkey could be tested with the countries of the Mediterranean zone having more or less similar conditions. Testing and comparing the mutual properties of countries will show the similarity and differences. Experiences gained from surveying and map making can be adopted for other countries in the Mediterranean. Common problems and mutual solutions for the broader Mediterranean areas will be derived from the shared experiences of the project. Existing soil surveys and maps could be gathered together and brought to a stage and compatible level for these countries. All information, observations, results and experiences could be exchanged and compared. Common methods and scale of works could be found. Data needs, modification requirements and adoption of methods and materials could be determined with the help of existing projects and their results. Field workers, together with administrators should work jointly and see the measures in the field. Countries should review each others' works and conditions. Among Mediterranean countries, most important erosion problem areas should be found and compared with each other.

A representative pilot region or regions should be selected and all the important problems should be shown with possible measures.

The reconnaissance level of soil surveying and the derived erosion map of Turkey have alerted politicians and government officials to the need to combat erosion in Turkey as well as in the Mediterranean coastal zones. The control of erosion in the Mediterranean zone is initiated with the result of this project. Without the scientific knowledge of existing soil conditions, erosion control plans cannot be made. International and national levels of planning are possible with existing maps. Erosion problems, location of problems, degree of environmental problems, state of natural resources and all possible control measures were more or less clarified after the project's appraisal. The importance of environmental development and control programme were well understood with the help of the survey. Similarity of Mediterranean zones helps to understand the identical environmental degradations and necessity of common protection plans.

Since this survey made the first appraisal of Turkey's national resources, similar works can be applied to make an initial appraisal of national resources in Mediterranean countries which have not yet done the same kind of surveying. If such works have been carried out, then, common erosion control and environmental protection plans can be prepared and put into practice.

Soil survey projects have supplied a scientific basis for the exchange of experience between Mediterranean countries with similar environments and it will help to promote the establishment of generally accepted soil and erosion classifications and nomenclatures. A common framework for more detailed investigations in developing areas of Mediterranean zones can be established. These results and maps have served as a basic document for educational, research and development activities.

One of the main purposes is to initiate international relations in this field. Therefore, in the field of soil erosion control, international contacts in the Mediterranean coastal zones could be strengthened. However, the transfer of experience from one country to another has usually been prevented by the problem that units of soil are described in a different manner. International contact and joint works will make international experts accept common terms and units so that standardisation will be achieved. International agencies will be provided with a general appraisal of the overall extent of the soil erosion problem of the Mediterranean coastal zone. International cooperation will be encouraged and assisted.

6.2 Possible cooperation forms among Mediterranean countries

By virtue of the fact that the processes of soil erosion constitute a continuous hazard to renewable resources production, international cooperation needs to be encouraged with other Mediterranean countries not involved in this map area, which are capable of cooperating and achieving the broader aims of this project. Some countries have been pursuing similar objectives without being committed to make or publish soil erosion maps. Certain countries have already made similar maps, without formal coordination with this programme.

Mediterranean countries should be formally invited to cooperate with UNEP in this Mediterranean Action Programme. All pertinent data will be collected and compiled for the purpose of designing a coordinated programme to produce a consistent Mediterranean erosion map. The Working Group will make an adequate soil erosion assessment in Mediterranean countries. It is clearly needed to intensify the action in the combating of soil erosion and to provide an essential component of sound land use planning based on land capability classification. It is recommended that national governments be encouraged to incorporate and apply soil erosion and environmental degradation assessment methodology in their action programmes for soil protection in areas especially vulnerable to erosion or critical for cultivation.

Under the guidance of UNEP one or more pilot areas should be selected and a case study of joint projects should be carried out. Common methodology and procedures should be developed for Mediterranean countries. Erosion maps of Mediterranean countries with joint projects will be drawn for the first stage as essential documents of erosion control works. After assessment and showing of the state of erosion, common erosion control measures and environmental protection methods should be developed as the second stage of the programme. Map scales should be equal to 1:20.000 or less than 1:20.000 for the purpose

of local project planning. The erosion map of Mediterranean countries will be the most essential document for further applied control projects. UNEP should lead the seminars and symposiums with related people in this field from Mediterranean countries. During the seminars and meetings, knowledge and experience will be exchanged among the nations. Field trips and practices will be conducted in the problem areas and regions. Among the countries, experts and planners can be exchanged and they will learn each other's problems. Problems and measures will be examined carefully in the field. In particular, exchanged experts will be field workers with field experience. Governmental relations will be made safe by UNEP or under UN Agencies. Financing of projects should be realised by coordinating Governments through UNEP. UNEP could prepare a list of experts from each country in the Mediterranean zone. Experts could be grouped and coded according to their specialisation. The facilities, opportunities, measures, sources and potential sources of each country in the Mediterranean zone should be compiled by RAC/PAP/MAP/UNEP. Every country active in this project should know the present and potential erosion states, kind and degrees of erosion of soils of each other. Most common problems and features of problems should be cleared for Mediterranean countries so that common joint projects should be started through UNEP with the help of each Government of the Mediterranean zone.

After all the necessary data are compiled and analysed, an urgent sound plan and programme could be prepared. This plan will be aimed to save natural resources, to protect the human environment and to develop resources for the benefit of the people.

6.3 Suggestions for future action

General surveying should be followed by detailed surveying at project planning level. A detailed study will lead to better maps. A map of 1:5.000 to 1:10.000 scale should be the next target of this programme. At this level of mapping, environmental and erosion control plans will be more realistic and precise.

After the conclusion of a reconnaissance study for all Mediterranean zones, the next step would be the beginning of erosion map drawing for all countries in this coastal region. Preparation of erosion map should be completed with the new organisation of works and groups. For the purpose of the erosion control plan, the erosion map of the Mediterranean zone will be the basic document.

To complete the erosion map, given steps of works should be followed in order.

1. Problems (kind, degree and location) should be listed and put into order of priority.

2. All the jobs which were completed should be listed and explained, so that they would shed light on future works of erosion.

3. All the jobs to be done should be listed and ordered.

4. Organisations and institutions which would be responsible for the works should be established.

5. Experts and technical people should be found or trained for the purpose of the project.

6. Rules, regulations and legislations and legal matters should be completed.

7. Coordinating the works and programme should be followed up by UNEP and FAO.

8. Standardisation and consistency of methods, terminology, applications, units and similar matters should be guaranteed. For this purpose, sub-committees should prepare a list of terminology, units and determine the methods to be used and other measures, application practices and scale of the works to be decided for the approval of the general committee.

9. Unity for design and application should be obtained among the countries.

10. Design of the project, application of the project and practices of the project on the land of required fields, should consider the people of the project area for each country. Economic, social and educational level of people at the present time should be considered in the project. Present and potential income of people should be evaluated, and new income sources should be found for people. Pressure on forest land should be relieved and erosion should be minimised with the opening of new income sources.

11. Projects should be realised according to people's benefit with the environmental protection measures.

12. Development of natural resources and protection of natural resources should be done simultaneously with people and for people.

7. CONCLUSIONS, RECOMMENDATIONS AND SUGGESTIONS

The erosion map of Turkey can be used for general planning because 60-65% precision can be obtained since the scale of the map is 1:1.000.000. To make a better map requires better soil surveying. But it was a great experience to do the soil surveying and to make the erosion map. Skills and confidence of field and office engineers were achieved. These works trained a number of necessary technicians and engineers. The problem was propagated, erosion was understood by different governmental institutions and enough publicity was generated. The importance of soil surveying and erosion maps was well understood. Whole works and efforts shed light on a matter of environmental and forest protection, especially erosion control. The value of land, water and forestry was well explained through these works.

As a result of observations and data, the new surveying and map making can be planned. After the present survey and erosion map, the soil of Turkey was reclassified for management units. According to properties, land use and limitations, soils of Turkey was divided into 79 management units with proposed conservation measures.

Erosion degrees form 0 to 4 and their areal distribution and percentages are given below:

Degree of erosion	Area hectares	Percent of Turkey
0 None	5 166 627	% 6.64
1 Slight	5 611 892	7.22
2 Moderate	15 592 750	20.04
3 Severe	28 334 933	36.42
4 Very severe	17 366 463	22.32
CK Rocky surfaces	2 930 933	3.77
Wind erosion	506 309	0.65

In the Mediterranean zone, 75% of land is under erosion effect as compared with 83% of Turkey under erosion effect. The following measures are suggested to stop erosion: (1) wise use of land according to capability classes, (2) cultural and vegetative measures which do not involve extra expense, (3) physical and mechanical measures. These are mainly contour farming, strip cropping, ripping, mulch farming, terracing, stone clearing and piling on contour, and gulley control. Besides technical measures, some other regulative and social measures are suggested as follows: (1) change of misused Class VI and VII cultivated land to range or forest by owners, (2) rearrangement of ownership boundaries to contour, (3) a grazing control system and restriction of free herding, (4) an independent organisation of more than 7.000 technical personnel, and (5) a comprehensive law covering the above mentioned items.

Proposed works can be realised in 50 years plus preparation time of 15 years. According to the planned yearly area of work: 721.000 ha, yearly allocation of money 266.4 billion T.L. To realise the works proposed here a new plan with more detail is needed. Such a plan can be based on a new soil survey.

The general soil management plan of Turkey was prepared for the period 1980 to 1986 from the documents of provincial soil maps of 1:100.000 scale and erosion maps of 1:1.000.000 scale which resulted from the general soil survey data. The work mainly is based on provincial soil maps. Soils of Turkey were grouped into 79 management units. Each unit was based on soil properties, land use and limitations. Unit land has homogeneous soil unit therefore similar requirements are needed. Land management suggestions and conservation measures of units are given in that report.

Technical and non-technical measures and practices of the work are considered and solution to problems are proposed in that study. An implementation of plan will last 50 years. To realise this plan more detailed information and data are required. One of the main handicaps of this surveying and erosion map is that the forest soils and forest land were not properly covered by this surveying. Soil survey was performed mainly over agricultural land. Forest land was not surveyed and the soil erosion map does not cover and does not represent the forest land and forest conditions. However, knowledge of forest land and forest conditions is very important in the erosion state and erosion control. A major cause of erosion comes from the destruction of forest and misuse of forest land. Erosion starts from the forest area so erosion will stop in the forest area.

In the next stage, a detailed soil survey should cover the forest lands too, otherwise observations, data and derived maps would not serve the purpose. The causes of floods will be diminished by keeping and regulating the surface runoff in the forest watershed. To control erosive agents in the covered uplands or water collecting area of forest means to save the downlands or low-lying agricultural lands from erosion. It is known that erosion mainly is caused by destruction of forest through wrong land use, forest fires and converting forest land into agricultural land. Therefore, present erosion conditions and potential erosion problems should be studied and surveyed in detail and maps should be drawn in the light of the new survey.

Another requirement of a successful project is trained personnel to realise the programme. Even at present, trained people are not sufficient to carry the weight of future projects. At the beginning of the project, more than 7,000 personnel should be trained in Turkey for future, 50-100 years' project. These people of different levels should be gathered into the new independent organisation where they would be the people to combat erosion. For the purpose of the control of erosion in the Mediterranean coastal zone, each member country should organise new institutions with newly-trained people to combat erosion in the Mediterranean coastal land. Then coordination among them should be carried out through UNEP.

Aerial photography could be applied to soil surveying and erosion study. Present land use can easily be determined by air-photos. For a detailed study and applied project, aerial photographs are very useful. Maps of 1:13.000 or 1:20.000 scale could be derived from airphotos. Application of aerial photographs are used in (1) forest inventory works, (20) afforestation and reforestation works, (3) pasture and range management, (4) determination of insect, fire and gas pollution and (5) forest cadastral works.

For general surveying, satellite remote sensing and landsat images can be used but for detailed study, air-photographs should be used. Aerial photography, photogrametry and photo-interpretation should be encouraged for soil surveying, erosion study, inventory of natural resources and for mapping. Photo-interpretation is used to determine the soil surface condition. Type of soil, degree of erosion and kind of land use could be determined by photo-interpretation. Therefore, aerial and surface methods should be combined for surveying and for mapping of project areas in Mediterranean coastal zones. It may be a good idea to organise new groups to deal with the application of aerial photography and satellite remote sensing in Mediterranean countries for the purpose of erosion study and environmental protection works.

To save the soil, one of the measures is to use land according to its capability. For this purpose, land should be divided into soil management units in Mediterranean zones, as was explained before.

To separate the soil management units, criteria should first be determined. After criteria are fixed, computer programmes could be prepared based on the criteria. Computer programmes would then supply the following outputs:

(i) according to properties of soil, land and erosion state with given criteria, the computer would classify the land for management units;

(ii) for given management units, according to assigned criteria, the computer would give land use type, erosion control measures and alternatives;

(iii) optimisation results for land use and control measures with alternatives will be listed;

(iv) land for dry farming, irrigated farming, forestry and grassland, meadows, and other lands will be divided;

(v) general and special treatment for each land division will be given.

8. REFERENCES

FAO/UNEP/UNESCO (1979). A Provisional Methodology for Soil Degradation Assessment, FAO, Rome.

FAO/UNESCO (1974). Soil Map of the World (Vol.I-V), Unesco, Paris.

FAO/UNEP/UNESCO (1982). World Soil Policy.

Soil-Water (Topraksu) (1979). Soil map of Turkey's Provinces and Reports, Ankara.

Soil-Water (Topraksu) (1981). Erosion map of Turkey, Ankara.

Annex I

Annex II

Rivers running toward the Mediterranean Sea

Annex III

Geology of Turkey

Annex IV

Lithology of Turkey

Annex V

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Annex VI

Soil map of Turkey (by I. Akyürek)

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Climatic regions of Turkey

Annex XII(a)

One hour maximum rainfall distribution of 5 years' frequency

Annex XIII(b)

One hour maximum rainfall distribution of 10 years' frequency

Annex XIII(c)

One hour maximum rainfall distribution of 25 years' frequency

Annex XIII(d)

One hour maximum rainfall distribution of 50 years' frequency

Annex XIII(e)

One hour maximum rainfall distribution of 100 years' frequency

Annex XIV

Erosivity of rainfall for Mediterranean zone

THE ISRAELI CONCEPT FOR RUNOFF AND EROSION CONTROL IN SEMI-ARID AND ARID ZONES IN THE MEDITERRANEAN BASIN

by

M. AGASSI, Y. BENYAMINI, J. MORIN, and S. MARISH
Soil Erosion Research Station Emek-hefer

and

E. HENKIN
Division of Soil Conservation and Drainage
Ministry of Agriculture
Tel-Aviv, Israel

PREFACE

The case study was prepared by members of the Research Unit, Division of Soil Conservation and Drainage, Israeli Ministry of Agriculture.

The studies reported here were conducted over the past 20 years in various parts of Israel.

The research unit was founded in the late fifties, in order to study problems of water and soil conservation and to develop methods of runoff and erosion control. The unit deals with studies of rainfall patterns, agrotechnical and chemical methods of soil and water conservation in the field, drainage systems (both surface and underground) and basic watershed research.

1. INTRODUCTION

The approach used in Israel for research and developing means to reduce and prevent erosion and water runoff, is based on years of local field-based and laboratory research. This approach is based on the inter-relationship between rainfall (intensities, frequencies, energy potential) and the physical and chemical properties of various soils.

For many years we have gathered erosion data in order to attempt to find a relationship between these data and The Universal Soil Loss Equation for predicting erosion, or with the modified equation developed by Williams. We did not find a valid relationship between actual data in Israel and computed values from the equations. In addition, we found that the actual measurements of erosion are complicated and expensive. Nor did we find a method for integrating the delivery ratio in our computations.

By measuring actual runoff and erosion under field conditions, and through the use of rainfall simulation, we concluded that by studying basic rainfall-soil relationships, it is possible to reach an understanding of the processes that bring about runoff and erosion and also to find relatively simple and inexpensive ways to reduce them. We found that under Israeli conditions, prevention or reducing runoff will in itself [illegible] prevention of erosion. Therefore it is not in practice necessary to [illegible] expensive and complicated direct erosion measurements, nor to develop erosion-prediction models.

On the other hand, we found that detailed studies of rainfall and soil properties with their mutual effect in initiating surface runoff, are required. We concluded that among all the various properties of rainfall, the accumulated kinetic energy property has the most direct effect on surface runoff.

We found that the stability of soils in relation to raindrops' impact and the ensuing soil crust development, is dependent on the chemical and physical properties of the soil. The density and the rate of the development of the crust which forms over the soil surface with the direct impact of the raindrops, has a direct influence on runoff and erosion rates.

The utilisation of rainfall simulators in the field and in the laboratory, accelerated our research and gave us the possibility of studying soil crusting processes under varying conditions of rainfall, soils and various soil treatments. Using these results as a basis, a formula was developed for predicting runoff in small watersheds (2-3 hectares) from actual rainfall. A high correlation was attained between the measured data under rainfall conditions and those computed according to the developed formula.

Understanding the process of soil crust formation and the factors for producing runoff, aided our efforts in developing economical and simple measures to prevent runoff and erosion. These measures are based principally on the maximum infiltration of rainfall as it reaches the soil and the reduction of rainfall movements on the soil surface. These principles are obtained by increasing surface water storage and developing methods that reduce the destructive force of raindrops as they strike the soil surface and create crusts.

The increasing agricultural use of various chemicals for fertilisation, weed control and pesticides, oblige us to prevent, as far as possible, surface runoff from the fields to waterways, rivers, lakes and the open sea.

Research has shown the direct relationship between the pollution of bodies of water and the accelerated agricultural development of the same watershed. Other research has shown that runoff and erosion from non-agricultural areas also contribute to the pollution of lakes and seas.

In Israel we have developed a national network of dual-purpose storage dams, which utilise both surface runoff and sewage effluent. The stored water is utilised for irrigation during the summer dry season. The importance of the storage dams is that they serve as a reliable source of water and provide an efficient means for sewage effluent disposal that in itself would have become a pollutant.

We believe that the approach found in Israel in research and in developing methods for reducing runoff and erosion and to utilise runoff and sewage effluent for irrigation, is appropriate for other arid and semi-arid areas in the Mediterranean Basin.

2. STUDY OF RAINFALL PATTERNS

Estimations of runoff and erosion are based on precipitation data and the properties of the soil. Information regarding the amount and intensity of rainfall is of great importance. The main source of rainfall data in Israel

is the Meteorological Service. More than seven hundred non-recording rain gauges and about eighty recording ones, form the official Israeli network. The average density of rainfall gauges is one non-recording rain gauge per 15 km^2 and one recording gauge per 150 km^2. About half of the stations have records going back about 50 years. Around 40% of the stations have records going back 30 years and in some stations, such as Jerusalem and Tiberias, there are records from over 130 years ago.

Rainfall parameters, like amount or intensity, have to be analysed for their probability of occurrence since many engineering and economic decisions are based on it.

Yearly and monthly amounts, as well as single rainstorm amount and rainfall intensity, are some of the rainfall data which have to be analysed for their probabilities. A summary of the rainstorm probability analysis methods which are used by the Israeli Soil Conservation Service is presented.

2.1 Methods and models for rainstorms probability analysis

Plotting position method

The simplest assumption regarding the sample frequency in its population is that the events correspond directly to their observed frequency. This is known as the California method (Lloyd, 1970) and is given by the general equation:

$$P = \frac{m}{n + 1} \qquad (1)$$

where m is the order of the rain desired parameter, m - being 1 for the largest one and n - for the smallest one, in n years of record. The probability P is thus the average of the probabilities of all events with rank m in series of periods each of n years. The common use of the method is to plot the actual parameter data with their P values on a log-probability paper.

A straight line which has the minimum deviation from plotted points, represents the desired probability relations. Any value of desired probability (Xpi) can be read from this line.

Log-normal method

Many phenomena in nature follow a normal distribution. Chow (1954) and others have shown that the logarithms of hydrological and rainfall data follow normal distributions more closely than the actual data. If Y is the logarithm (1/nx) of a variable Xi normally distributed, then the variable Xi is said to be logarithmic normally distributed.

$$P_{(x)} = \frac{1}{X\sigma_Y\sqrt{2\pi}} \cdot e^{-\frac{(Y-\mu_Y)^2}{2\sigma^2_Y}} \qquad (2)$$

Thus where μy and σy are the mean and standard deviation of the natural logarithms of Xi. If we assume that $\mu y \approx y$ and $\sigma y \approx Sy$ for the rank of the available data, then we can estimate the size of an event (Xpi) for any desired probability Pi by:

$$Yp_i = Zp_i \cdot Sy + \bar{Y} \quad (3)$$

$$\text{then} \quad \boxed{Xp_i = e^{Yp_i}} \quad (4)$$

when Zpi - the standard normal deviate for probability (Pi)

$$\bar{Y} = \frac{\sum \ln X_i}{n} \quad (5)$$

$$S_y = \sqrt{\frac{\sum(\ln x_i)^2 - (\sum \ln x_i)^2/n}{n-1}} \quad (6)$$

Chow method

The hydrologic or rainfall events can be predicted by the log probability low, proposed by Chow (1954).

The parameter value for any desired probability - X pi, can be calculated according to Chow the method by:

$$\boxed{Xp_i = \bar{X}(1 + Cv\,K)} \quad (7)$$

when $\bar{X}$ = the average of the recorded data

Cv = coefficient of variation

$$Cv = \frac{Sx}{\bar{x}} \qquad \text{(Sx = standard deviation)}$$

K = the Frequency Factor, depends on the low of occurrence and the standard of deviation of the data. K can be calculated by Chow the method as:

$$K = \frac{e^{\sigma y \cdot zpi - \sigma^2 y/2} - 1}{(e^{\sigma^2 y} - 1)^{1/2}} \quad (8)$$

$(\sigma y \approx Sy)$ see equation 6

Gumbel method

For the extreme values of rainfall or hydrologic events like the annual maximum flood or rainstorm, Gumbel (1958) suggested the exponential probability relations. According to this method, the predicted extreme value for any probability can be evaluated by:

$$\boxed{Xpi = \frac{Y \cdot Sx + \beta}{1.28255}} \quad (9)$$

$$\text{when } y = -\ln[-\ln(1-Pi)]$$

$$\beta = \bar{x} - 0.45\,Sx$$

when $y = -\ln[-\ln(1-Pi)]$

$$\beta = \bar{\bar{x}} - 0.45\ Sx$$

Detailed information for the different probability analysis and parameters estimation is given by G.W. Kinte (1977).

Most of the rainfall data in Israel as well as in most parts of the world, are limited by the short period of actual measurements. Since all the prediction methods are based principally on past data, the absolute validity of the predicted values is uncertain. This is especially true for the most important low probability events. Since there is no way to be sure as to which of the prediction methods is superior, we decided to present to our economists and engineers all the prediction range as calculated by the different methods.

2.2 Rainstorm analysis

Rain volume

The yearly and monthly rainfall data is obtained from the standard daily rain measurements at 8 a.m. In Tables I and II the yearly and monthly rain volumes for one station, as well as the predicted values for some given probabilities are presented.

Since erosion and flood control problems are connected directly to rainstorms and to the total yearly and monthly rain volume, the storm analysis is the most important part of the rainfall evaluation.

A rainstorm is defined as the amount of rainfall in a period of time in which the intervals between the rainfall segments do not exceed 24 hours. The maximum rainstorm probability for each of the winter months is essential for runoff and flood prediction. This information is presented in Table III.

Rain intensity

A typical recorded rain gauge chart is given in Fig. 1. The graph on the chart is cumulative rainfall curve, the slope of the graph being proportional to the intensity of the rainfall.

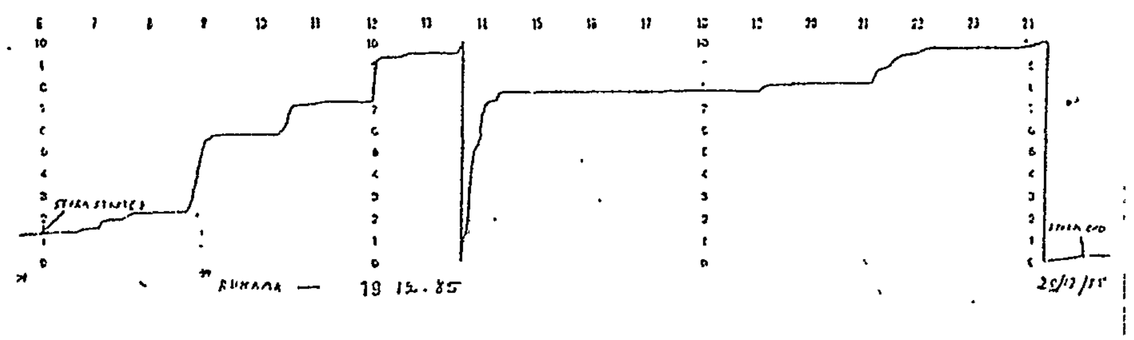


Fig.1 Rainstorm chart of Ruhama 19/12/85

Table I

The annual precipitation data and predicted values
Station No. 144001 SAAD

Annual precipitations

N	Frequency %	Rain mm	Year
1	3.4	637.4	1956/57
2	6.9	622.0	1964/65
3	10.3	582.4	1963/64
4	13.8	565.7	1979/80
5	17.2	556.2	1955/56
6	20.7	518.8	1973/74
7	24.1	517.4	1966/67
8	27.6	506.1	1951/52
9	31.0	465.8	1971/72
10	34.5	458.7	1974/75
11	37.9	454.9	1967/68
12	41.4	424.1	1953/54
13	44.8	401.7	1960/61
14	48.3	384.7	1970/71
15	51.7	370.8	1949/50
16	55.2	370.6	1976/77
17	58.6	358.7	1958/59
18	62.1	354.5	1972/73
19	65.5	345.3	1957/58
20	69.0	338.6	1968/69
21	72.4	329.1	1954/55
22	75.9	310.0	1978/79
23	79.3	278.9	1952/53
24	82.8	271.4	1950/51
25	86.2	248.0	1975/76
26	89.7	246.9	1965/66
27	93.1	216.0	1969/70
28	96.6	41.2	1959/60

Frequency	Rain (mm)
5%	630.4
10%	586.3
20%	526.2
30%	477.8
40%	436.4
50%	377.7
60%	357.0
70%	335.7
80%	277.4
90%	243.8
95%	119.7

CVD = 0.343 S = 137.06 AVE = 399.14

Predicted values of annual rainfall (mm) according to the different methods of rainfall probability analysis

Pi%	Chow	Gumbel	Log normal
1.	820.4	829.1	1220.2
5.	653.7	654.9	856.4
10.	585.3	577.9	709.4
20.	500.0	497.8	564.5
50.	377.6	376.6	364.7
80.	285.0	286.6	235.6
90.	249.5	248.3	187.5
95.	218.4	220.2	155.3
99.	173.8	174.3	108.1

Table II

The precipitations for November and the predicted values
Station No. 144001 SAAD

Precipitations in November

N	Frequency %	Rain mm	Year
1	3.3	212.8	1953/54
2	6.7	163.8	1967/68
3	10.0	161.4	1955/56
4	13.3	143.0	1957/58
5	16.7	119.2	1954/55
6	20.0	101.4	1971/72
7	23.3	100.5	1974/75
8	26.7	80.6	1972/73
9	30.0	79.2	1973/74
10	33.3	69.2	1963/64
11	36.7	64.1	1979/80
12	40.0	61.5	1956/57
13	43.3	59.1	1964/65
14	46.7	46.4	1960/61
15	50.0	43.7	1970/71
16	53.3	38.2	1978/79
17	56.7	31.4	1976/77
18	60.0	25.8	1969/70
19	63.3	24.9	1952/53
20	66.7	23.1	1975/76
21	70.0	22.9	1951/52
22	73.3	21.5	1965/66
23	76.7	20.8	1968/69
24	80.0	12.8	1950/51
25	83.3	8.0	1959/60
26	86.7	7.4	1949/50
27	90.0	3.5	1958/59
28	93.3	1.5	1977/78
29	96.7	1.1	1966/67

Frequency	Rain (mm)
5%	188.2
10%	161.4
20%	101.4
30%	79.2
40%	61.5
50%	43.7
60%	25.8
70%	22.9
80%	12.8
90%	3.5
95%	1.3

CVD = 0.923 S = 55.66 AVE = 60.30

Predicted values of monthly rainfall (mm) according to the different methods of rainfall probability analysis

Pi%	Chow	Gumbel	Log normal
1.	275.4	234.9	760.4
5.	161.3	164.1	304.4
10.	120.0	132.9	187.0
20.	86.0	100.3	103.6
50.	44.2	51.2	33.5
80.	22.9	14.6	10.8
90.	16.2	-0.9	6.0
95.	12.2	-12.4	3.7
99.	7.1	-31.0	1.5

Table III

The maximum precipitations for a rainstorm in December and predicted values : Station No. 144001 SAAD

Maximal rainstorm in December

N	Frequency %	Rain (mm)	Year	Storm started day	Storm duration days
1	3.2	211.5	1951/52	13	8
2	6.5	169.3	1966/67	17	5
3	9.7	105.7	1963/64	1	3
4	12.9	101.7	1968/69	4	5
5	16.1	98.4	1953/54	14	7
6	19.4	95.7	1977/78	21	3
7	22.6	87.9	1970/71	5	9
8	25.8	86.1	1956/57	5	6
9	29.0	80.4	1980/81	10	8
10	32.3	68.9	1949/50	20	5
11	35.5	64.7	1954/55	5	2
12	38.7	64.7	1971/72	5	4
13	41.9	63.7	1979/80	26	3
14	45.2	61.6	1974/75	3	4
15	48.4	56.9	1955/56	6	2
16	51.6	43.6	1978/79	1	2
17	54.8	40.8	1964/65	12	4
18	58.1	36.6	1972/73	18	4
19	61.3	36.2	1976/77	28	4
20	64.5	33.7	1975/76	8	3
21	67.7	31.7	1957/58	8	2
22	71.0	20.3	1950/51	4	2
23	74.2	19.6	1973/74	16	2
24	77.4	14.0	1952/53	27	2
25	80.6	13.9	1969/70	30	2
26	83.9	11.0	1967/68	29	2
27	87.1	4.8	1958/59	3	1
28	90.3	4.8	1960/61	5	2
29	93.5	3.2	1965/66	19	1
30	96.8	1.5	1959/60	26	1

CVD = 0.846 S = 48.84 AVE = 57.76

The predicted values in mm of rain

Pi%	Chow	Gumbel	Log normal
1.	243.4	211.0	583.4
5.	147.8	148.9	257.0
10.	111.5	121.5	166.1
20.	82.0	92.9	97.9
50.	44.1	49.7	35.6
80.	23.8	17.7	12.9
90.	17.2	.0	7.6
95.	13.4	.0	4.9
99.	8.0	.0	2.2

Technically, rainstorm analysis starts with the recording of each inflection point on the graph by a digitiser.

The analysis of the rainstorm chart of 19/12/85 from Ruhama station shown in Fig.1, is presented in Fig.2 (a, b and c). The rainstorm was analysed into segments of rain, each segment presenting a certain period of time with uniform intensity.

In Fig.2c the grouping of the storm intensity volume regardless of the rank and sequence is presented. For example, segments 19 and 22 have intensity between 6 and 7 mm/h with total volume of 0.63 + 0.69 = 1,32 mm.

It is obvious that 35,8% of the rainstorm volume is below the intensity of 7 mm/h. The maximum rain intensity for continuous 30 minutes of rainfall is 15,65 mm/h, which falls between segments 19-23.

Storm kinetic energy and erosivity

Soil erosion prediction and calculation by the U.S.L.E. (Universal Soil Loss Equation) erosion model (Wischmeier, 1959) demonstrates the methods to calculate storm kinetic energy E and erosivity R (see agricultural handbook 537). The storm kinetic energy can be computed as the sum of each rain intensity group li by:

$$E = \quad (210+89 \log_{10} li) \quad \text{(in metric system)} \qquad (10)$$

when: E - Kinetic energy, in jouls/m^2
li - Rain intensity, in cm/h
Di - Rain depth for the intensity group li of the rainstorm, in mm.

The erosivity parameter R according to the U.S.L.E. model, presents the best linear relation between soil erosion and the rainstorm erosivity.

$$R = E. \quad _{30} \text{ Jouls/m hour} \qquad (11)$$

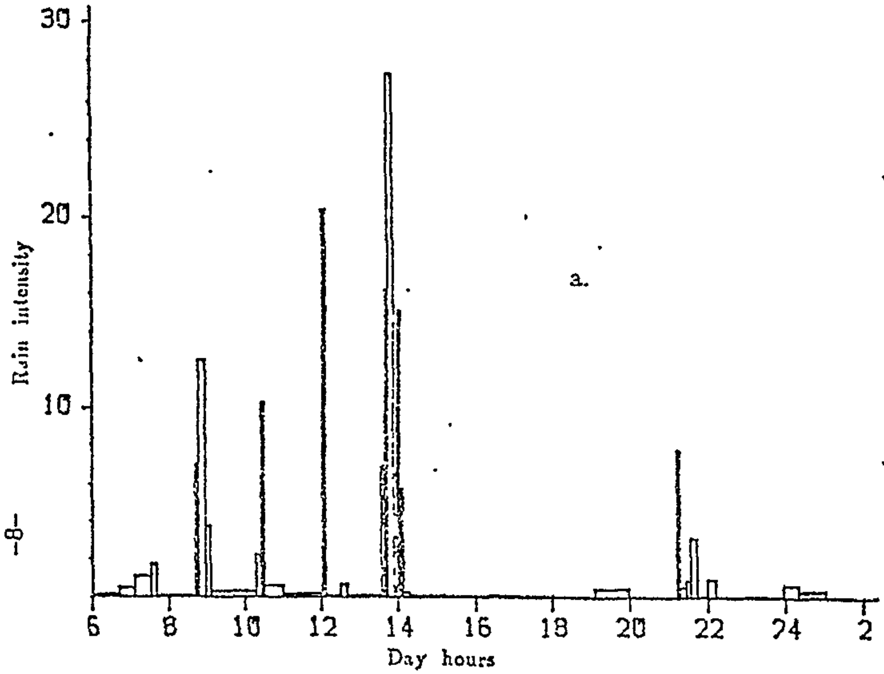
When: R - erosivity, joules/m hr
$_{30}$ - the maximum rain intensity for a continuous 30 minutes of rainfall, m/hr.

Probability analysis

The sum of the annual rainstorm erosivity probability analysis for the Yavne Station is shown in Fig.3. It was previously emphasised that since the best predicted values are uncertain, it is better to present the range of the values as calculated by the different methods.

Fig.3 presents a sample for this type of probability calculations. In the upper left part of Fig.3a, the calculated annual storm erosivity is shown.

The probability distribution of the annual storm erosivity for the Gumble, normal, log-normal and Chow methods are presented in Table 3b for a rank of given probabilities. The standard deviation of each method represents the standard deviation of the model calculating values from the data when the model probabilities were taken as the data frequencies. The star sign in graph c shows the actual measured data located in their frequency position according to equation 1.



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b.

RUHAMA 19/12/85 – Rain segment detailed and sequence.

SEGMENT	FROM TIME HOUR	TO TIME HOUR	INTENSITY mm/h	VOLUME mm	ACUM.VOLUME mm	DELTA T HOUR
1	6.00	6.19	0.07	0.01	0.01	0.19
2	6.19	6.71	0.12	0.07	0.08	0.52
3	6.71	7.11	0,46	0.18	0.26	0.39
4	7.11	7.52	1,04	0.43	0.69	0.41
5	7.52	7.68	1.69	0.26	0.95	0.15
6	7.68	8.68	0.09	0.09	1.05	1.00
7	8.68	8.73	7.06	0.71	1.75	0.10
8	8.73	8.96	12.64	2.27	4.03	0.18
9	8.96	9.08	3.77	0.47	4.50	0.12
10	9.08	10.29	0.27	0.33	4.82	1.21
11	10.29	10.42	2.21	0.29	5.11	0.13
12	10.42	10.51	10.31	0.88	5.99	0.08
13	10.51	11.00	0.59	0.29	6.28	0.49
14	11.00	12.01	0.18	0.18	6.46	1.01
15	12.01	12.11	20.53	2.05	8.51	0.10
16	12.11	12.50	0.10	0.04	8.55	0.33
17	12.50	12.65	0,67	0.10	8.66	0.15
18	12.65	13.55	0.10	0.09	8.75	0.90
19	13.55	13.64	6.97	0.63	9.37	0.09
20	13.64	13.73	16.30	1.39	10.76	0.08
21	13.73	13.87	27.55	3.86	14.62	0.14
22	13.87	13.97	6.60	0.69	15.31	0.10
23	13.97	14.06	15.23	1.29	16.60	0.08
24	14.06	14.14	5.85	0.50	17.10	0.08
25	14.24	14.25	0.29	0.04	17.14	0.13
26	14.28	17.98	0.11	0.39	17.53	3.70
27	17.98	19.08	0.02	0.03	17.56	1.10
28	19.03	19.94	0.44	0.38	17.94	0.85
29	19.94	21.17	0.05	0.07	18.00	1.23
30	21.17	21.26	7.84	0.67	18.67	0,08
31	21.26	21.42	0.55	0.09	18.76	0.16
32	21.42	21.54	0.91	0.10	18.87	0.11
33	21.54	21.69	3.14	0.47	19.34	0.15
34	21.69	21.95	0.10	0.03	19.36	0.27
35	21.95	22.16	0.96	0.20	19.56	0.20
36	22.16	23.91	0.09	0.16	19.72	1.75
37	23.91	0.30	0.64	0.25	19.96	0.39
38	0.30	1.00	0.34	0.24	20.20	0.70

c.

RAIN VOLUMES IN DIFFERENT GROUPS OF INTENSITY

INTENSITY mm/h	VOLUME CE. mm	ACUMULATED PERCENTAGE
0,00	3.35	16.57%
1.00	0,69	20,00%
2,00	0.29	21.42%
3,00	0.94	26.08%
5,00	0.50	28.54%
6.00	1.32	35.08%
7,00	1.37	41.88%
10,00	0.88	46.21%
12,00	2.27	57,43%
15.00	1,29	63,83%
16,00	1.39	70,74%
20,00	2,05	80,91%
27,00	3,36	100,00%

STORM KINETIC ENERGY = 398.31 JOULS/m^2

THE MAX. INTENSITY FOR 30 MIN. WAS : 15.65 mm/h AT SEGMENT 19–23

EROSIVITY (R) = 6.23 JOULS/m·h

Fig.2 Rainstorm analysis, Ruhama, 19/12/85

a

THE ANNUAL RAIN STORMS EROSIVITY (JOULS/m.h)

1958/59	58.2	1959/60	62.3	1960/61	262.7	1961/62	192.5
1962/63	454.6	1963/64	212.7	1964/65	407.8	1965/66	49.4
1966/67	201.6	1967/68	124.3	1968/69	290.0	1969/70	86.5
1970/71	289.4	1971/72	162.7	1972/73	111.7	1973/74	456.0
1974/75	504.8	1975/76	48.7	1976/77	236.7	1977/78	240.8
1978/79	170.3	1979/80	275.3				

x= 22.7 y= 5.1860 Sx= 137.6 Sy= 0.7279 n= 22

b

PROBABILITY DISTRIBUTION

(%)	GUMBLE	NORMAL	Log. NOR.	CHOW
1	654.2	542.7	972.0	744.7
5	479.4	449.0	591.9	476.2
10	402.2	399.0	454.3	379.1
20	321.7	338.5	329.8	291.1
50	200.1	222.7	178.8	184.4
80	109.8	106.9	96.9	126.6
90	71.3	46.4	70.3	107.8
95	43.1	0.0	54.0	96.3
99	0.0	0.0	32.9	81.3
SDV.	27.19	29.52	55.32	44.85

d

CHI SQ. TEST

	≤ 86	86–201	201–275	> 275	PROBABILITY FITNESS (%)
DATA	5	6	5	6	
GUMBLE	2.982	8.121	4.498	6.398	57.246
NORMAL	3 545	6.112	4.622	7.721	79.797
Log. NOR.	3 508	8 933	3 478	6.081	51 936
CHOW	0 445	12 084	4.454	5 017	0 000

c

THE ANNUAL RAIN STORMS EROSIVITY (JOULS/m h)

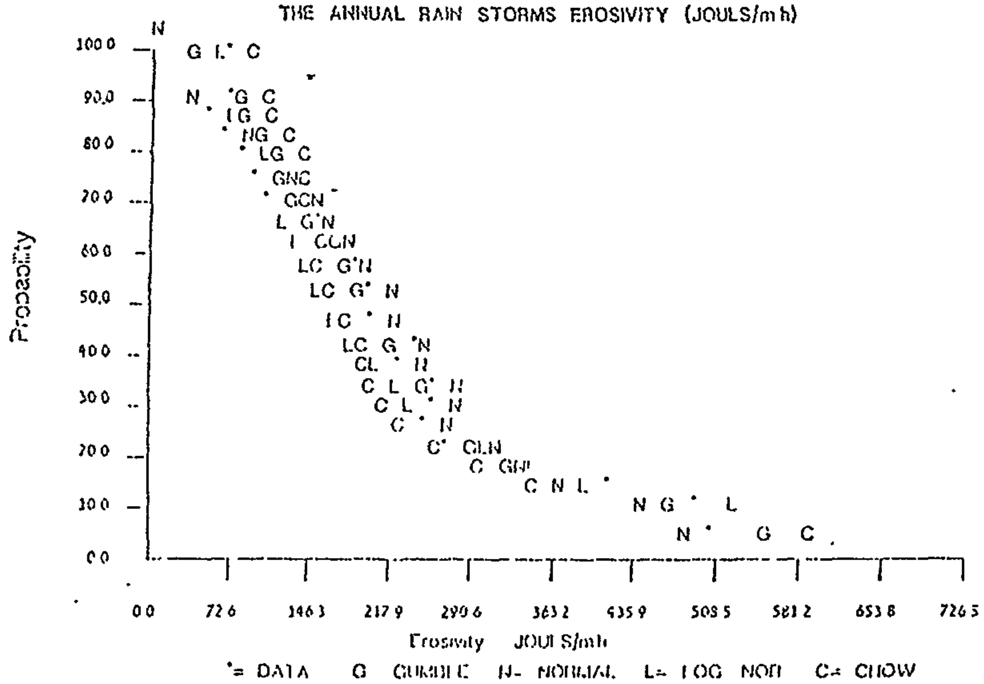


Fig.3 Probability analysis of the annual rainstorms erosivity

It is obvious that there is no agreement between the Chi sq. test and the minimum standard deviation. However, in general, the range of values might serve as the best guide for economists and engineers. The same system of analysis is applied to other long-term rain and hydrologic data like the highest intensity for different time duration, rainstorm kinetic energy for any desired period, etc.

For each of the models, the calculated values are presented for these same frequencies. Chi sq. test was conducted between the data and each model value (Fig.3d). The Chi sq. tests were conducted by comparing the numbers of events in each of the data groups cells and the predicted values for the same cells borders. The probability fitness (p(X)* is presented in the last column of Fig.3d:

$$^{*}P(\chi^2) = 1 - \int_0^{\chi^2} f(u)du = Pi(x > \chi^2)$$

2.3 Rainfall - runoff inter-relationships

In many arid and semi-arid areas the phenomenon of surface runoff can be attributed to the formation of surface crust. This crust, less than 1 mm thick, is formed by the combined action of the kinetic energy of the falling raindrops (McIntyre, 1958) and the dispersive effect of the rainwater, virtually devoid of electrolytes (Agassi et al., 1981, 1985).

The runoff of a given rainstorm is a function of the soil infiltration rate, surface storage capacity and rainfall intensity distribution and sequence, during the particular rainstorm event.

*Soil infiltration rate can be mathematically described as a function of the cumulative rainstorm and a number of soil parameters. Morin and Benyamini (1977) described the infiltration rates (lt) of bare soil under rain by the following equation:

$$I_t = I_f + (I_i - I_f)\exp(-\gamma p t) \qquad (12)$$

when

l_i = initial infiltration rates of the soil - mm/h

l_f = final (constant) infiltration rates of the soil - mm/h

t = time from the beginning of the rain - sec.

γ = soil coefficient related to aggregate stability while forming the crust - 1/mm

p = rain intensity - mm/h

Equation (12) describes the effect of the building up of a continuous crust over the surface. The relatively impermeable crust is the main infiltrability controlling parameter.

Infiltration functions

In order to calculate the infiltration functions for different soil crust conditions, field experiments with rainfall simulations were conducted. In these experiments, the soil was subjected to rainfall simulations in different periods of intervals between the rainstorms. The conditions studied were (Morin and Benyamini, 1977):

(a) initially dry uncrusted soil (first rain on dry seedbed)
(b) initially dry crusted soil (second rain after 7 days)
(c) initially wet crusted soil (second rain after 1 day)

Fig.4 (a,b,c) presents the infiltration rate as a function of the cumulative rain for a calcic Luvisol (Loess), as measured in the field by the rainfall simulator.

Calculation of surface runoff

Surface runoff predictions were calculated by combining the appropriate infiltration equation with rainfall data taken from recording rain gauge charts. The integral of equation (12) which describes the infiltration rate, gives the total amount of rainfall that can infiltrate into the soil during a given time. In the same way, the amount of infiltration during any time segment of a storm is given by equation (13).

$$F_{\Delta t_i} = I_f \Delta t_i + \frac{(I_i - I_f)}{-\gamma P_i} \left[\exp(-\gamma D_i) - \exp(-\gamma D_{i-1})\right] \tag{13}$$

where $F_{\Delta t_i}$ = the potential infiltration (mm) of any time segment Δt_i(h)

With the rain intensity P_i (mm·h^{-1}); $D_i = \sum_{i=1}^{n} P_i t_i$, the cumulative rainfall up to the time t_i(mm); and all other parameters as in equation (12)

The surface runoff of a storm with varying rainfall rates can be calculated by equation (14) which is evaluated for individual time segments during which excess rainfall occurred, taking into consideration not only excess of rainfall rate over infiltration rate, but also whether surface detention and surface storage were satisfied prior to runoff initiation.

$$\sum_{i=1}^{n} R_i = \sum_{i=1}^{n} (P_i \Delta t_i + SD_{i-1} - F_{\Delta t_i} - SD_m) \tag{14}$$

where: R_i - surface runoff (mm); SD_i = surface storage and detention (mm) for the time segment Δt_i; SD_m = maximum surface storage and detention (mm); and all other parameters are as above.

Values of SD_m are iterated from an initial value of zero to any desired predetermined value. The SD_m value for a particular soil and tillage condition may be determined empirically using the rainfall simulator.

For the specific case of the basin tillage (Unger, 1984), where the surface storage is concentrated in only a part of the total surface area, one must modify the term $F_{\Delta t_i}$ in equation (14) and define it as $F^*_{\Delta t_i}$ as follows, when

$$F_{\Delta t_i} > P_i \Delta t_i : F^*_{\Delta t_i} = K \cdot F_{\Delta t_i} + P_i \Delta t_i (1 - K) \tag{15a}$$

and when

$$F_{\Delta t_i} \leq P_i \Delta t_i : F^*_{\Delta t_i} = F_{\Delta t_i} \tag{15b}$$

K is that portion of the area occupied by the basins.

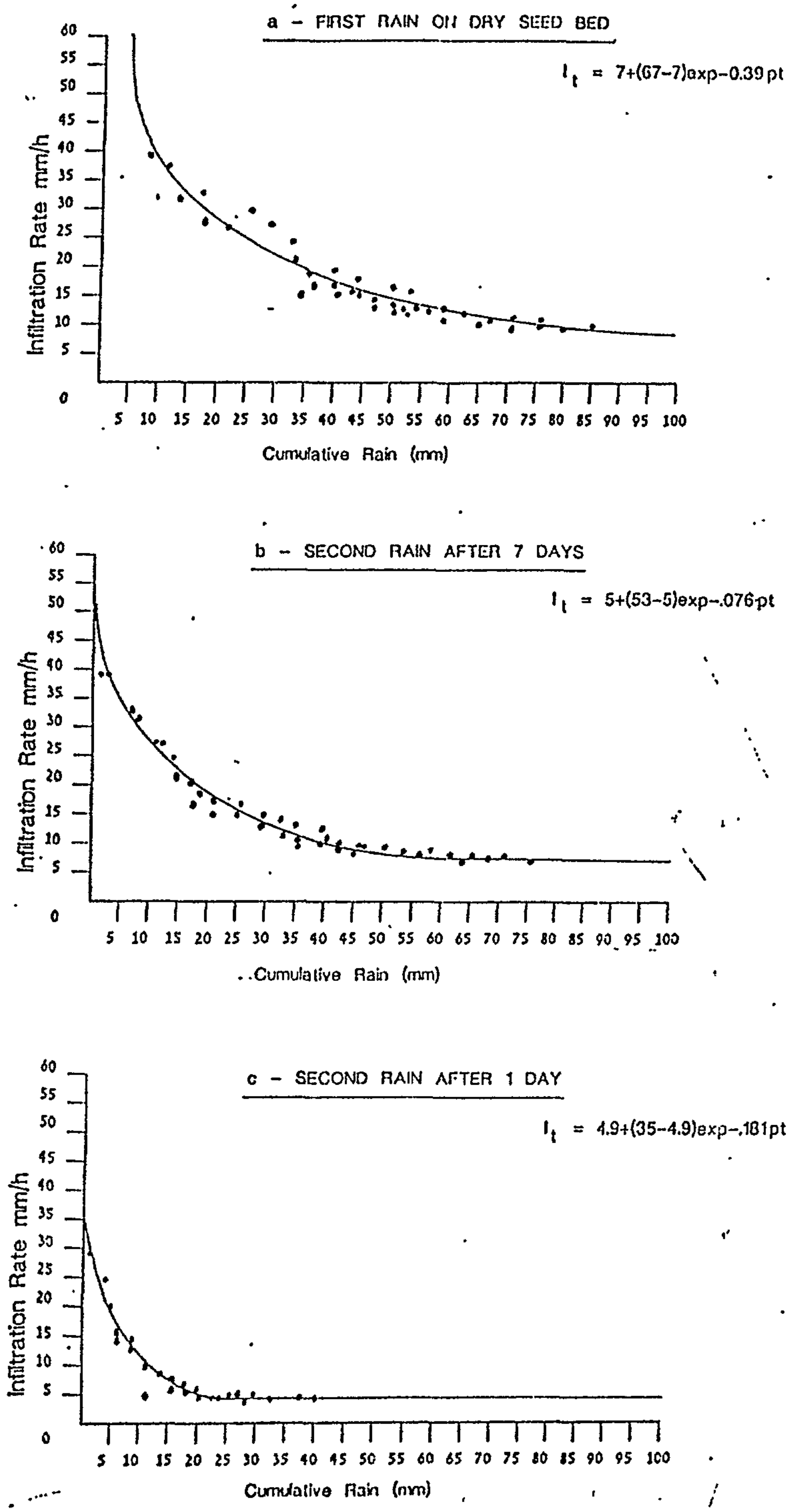


Fig.4 Infiltration rate as a function of cumulative rainfall, different rain storms cycle.

In Fig.5 a,b, the runoff calculation method is presented. The infiltration rate decreases sharply with the increase in rain intensity. The effect of the surface storage and detention (SDm) on the runoff is considerable. In Fig.5a, the SDm was 0,5 mm and the runoff was 12.02 mm, compared to 1.02 mm when the SDm was 10 mm (Fig.5b). The relationships between rainfall, SDm and runoff are very well illustrated in Fig.6.

Figs 5 and 6 show that runoff was induced especially when high intensity of rainfall segments occurred when the infiltration was low.

The effect of the SDm on the cumulative runoff is obvious. Since there are segments of very low rainfall or no rainfall at all during the rainstorm, the surface storage is a dynamic parameter which can absorb rainwater during the rainstorm, much more than its nominal volume.

A comparison between predicted and measured runoff for a single rainstorm is presented in Fig.7. A close correlation between the predicted and measured runoff was found for a variety of soils and soil surface conditions.

Long-term evaluation

Ideally, an evaluation of alternative tillage and management practices for a given region should be based on actual long-term observed runoff data. However, in many cases such data are not available, while standard meteorological data are much more easily obtained. Since in actual practice, management decisions will be made whether or not firmly-based recommendations have been developed, we suggest that design specifications based on historic rainfall records and present soil characteristics provide a reasonable interim recommendation. This analysis provides valuable guidelines for planning research aimed at obtaining the long-term runoff data mentioned above.

Total infiltration of rainwater per unit area may be increased by maintaining high soil infiltrability and also by increasing the surface storage.

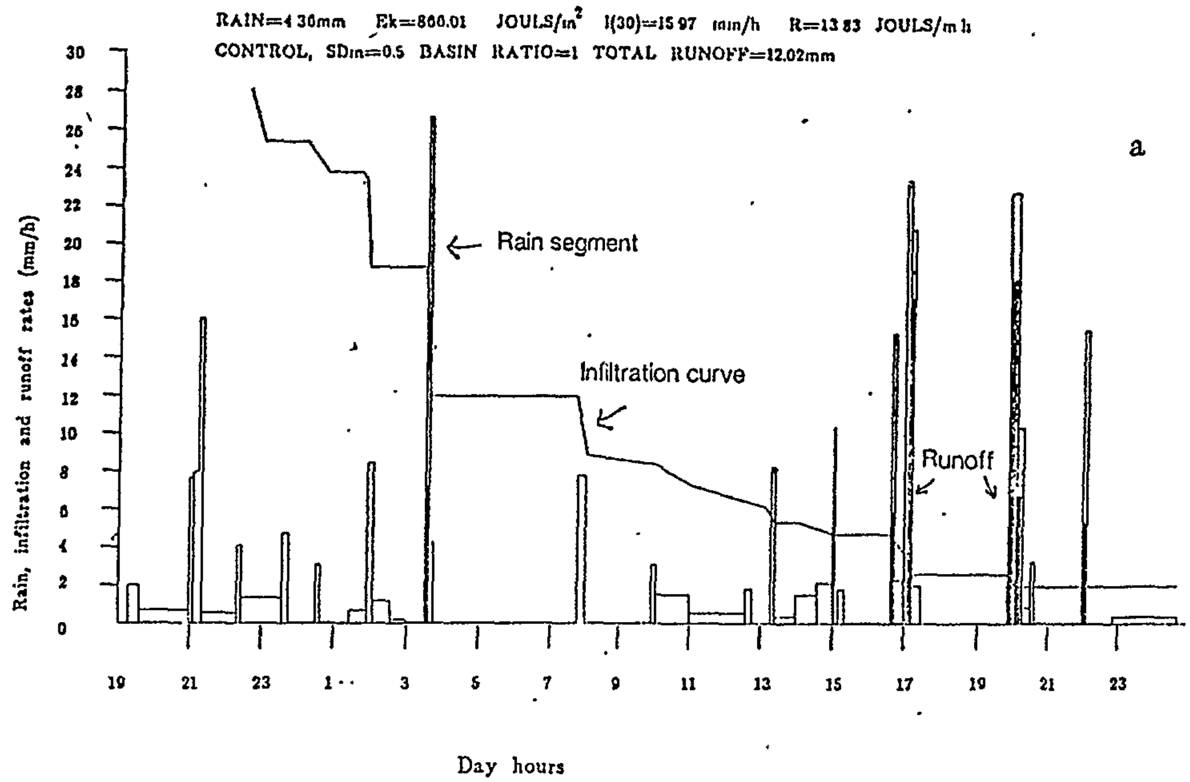
Fig.8 demonstrates the importance of the infiltration rate and surface storage on runoff control. The seasonal runoff from cotton or wheat fields in calcic luvisol soil will reach 165 mm and 85 mm for the 10 and 50% probability. Phosphogypsum application or increasing the soil surface storage (these phenomena will be discussed in detail in sections 6 and 7), will reduce the runoff for the 10 and 50% probability to 55-60 and 26 mm respectively. Combining the two amendments together will reduce seasonal runoff to 10 and 2 mm for the 10 and 50% probability.

3. THE EFFECT OF SOME PHYSICAL PROPERTIES OF THE SOIL ON FILTRATION RATES

3.1 Foreword

The decrease of infiltration rate under rainfall storms is a result of two main processes, the decrease of the hydraulic gradient and the crust formation.

The crust is formed by the combined action of the kinetic energy of falling drops (McIntyre, 1958) and the dispersive effect of the rainwater which is virtually devoid of electrolytes (Agassi et al., 1981).



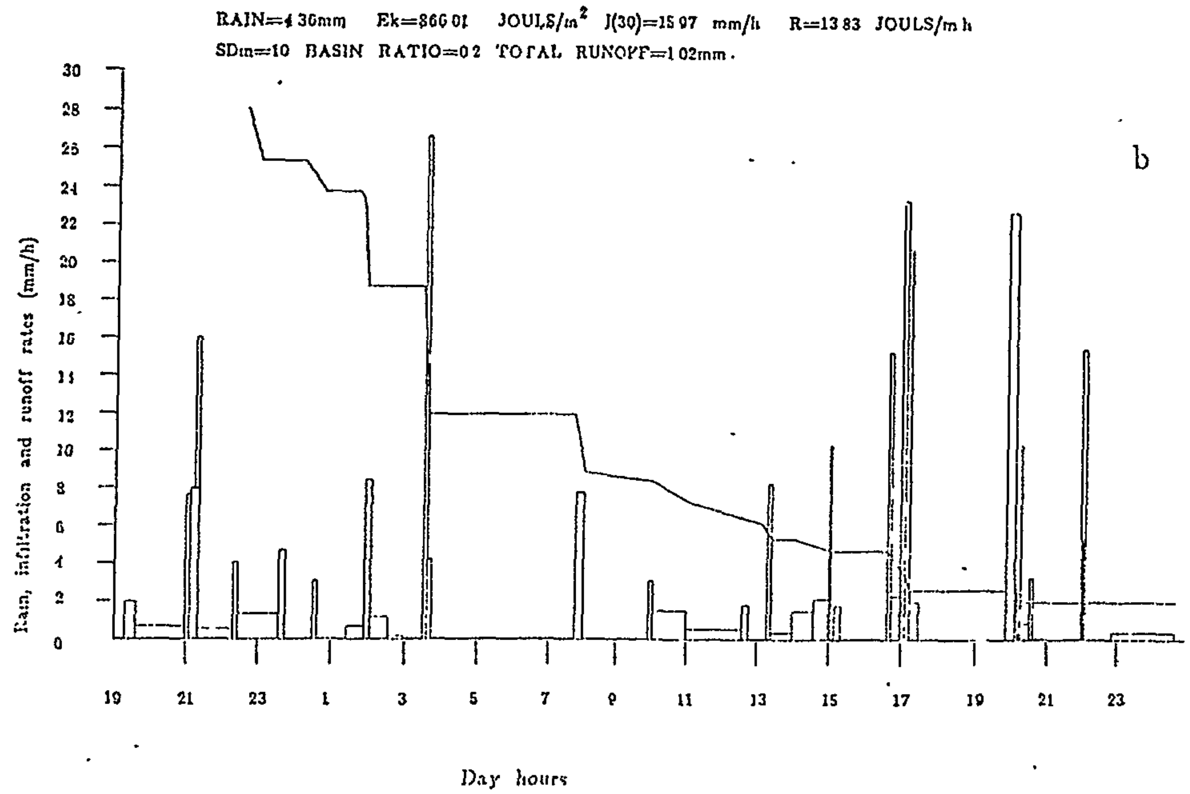


Fig.5 Rainfall, infiltration and runoff rates for the 26/01/84 rainstorm in Shoresh

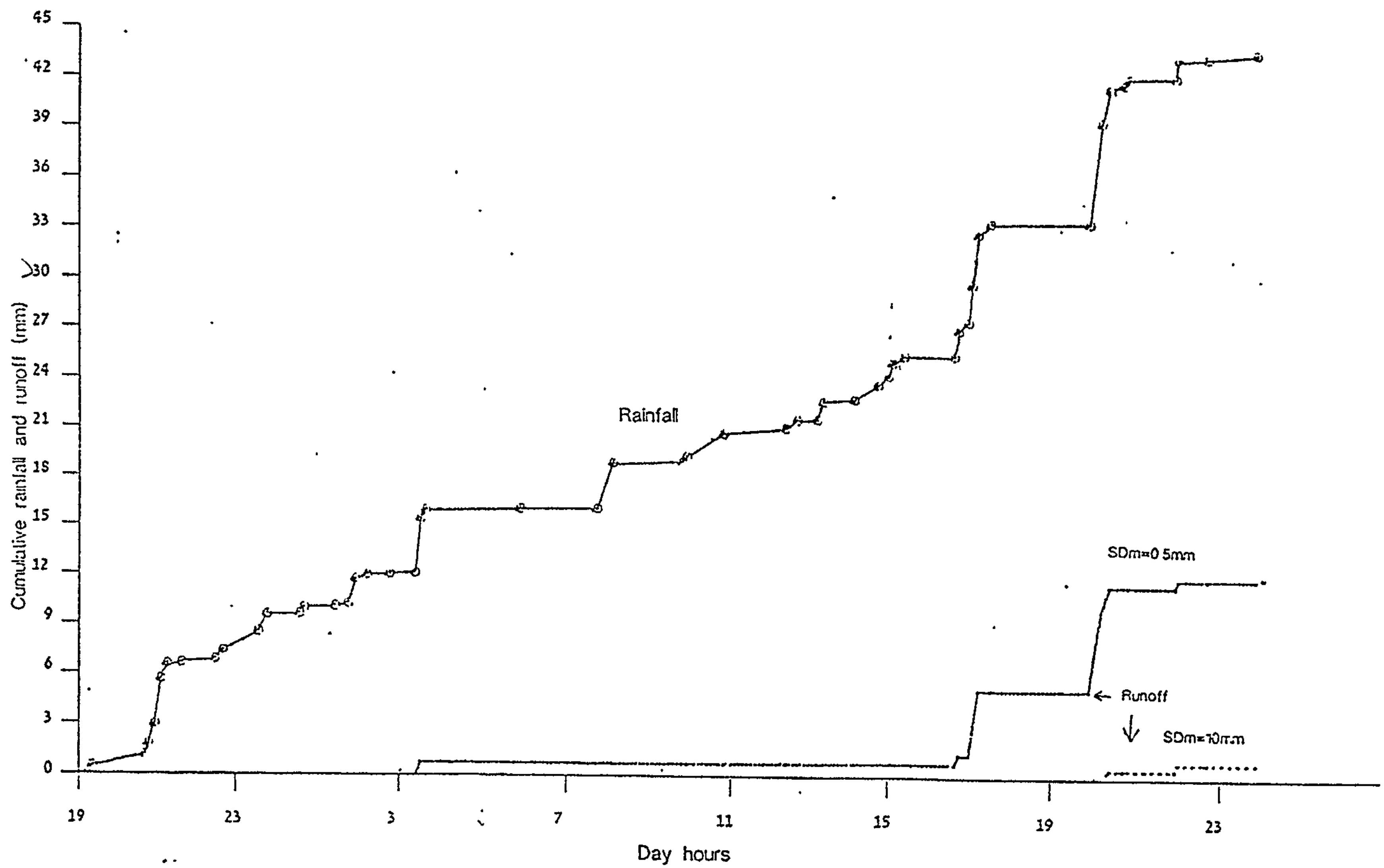


Fig.6 Cumulative rainfall and runoff for the 26/01/84 rainstorm in Shoresh.

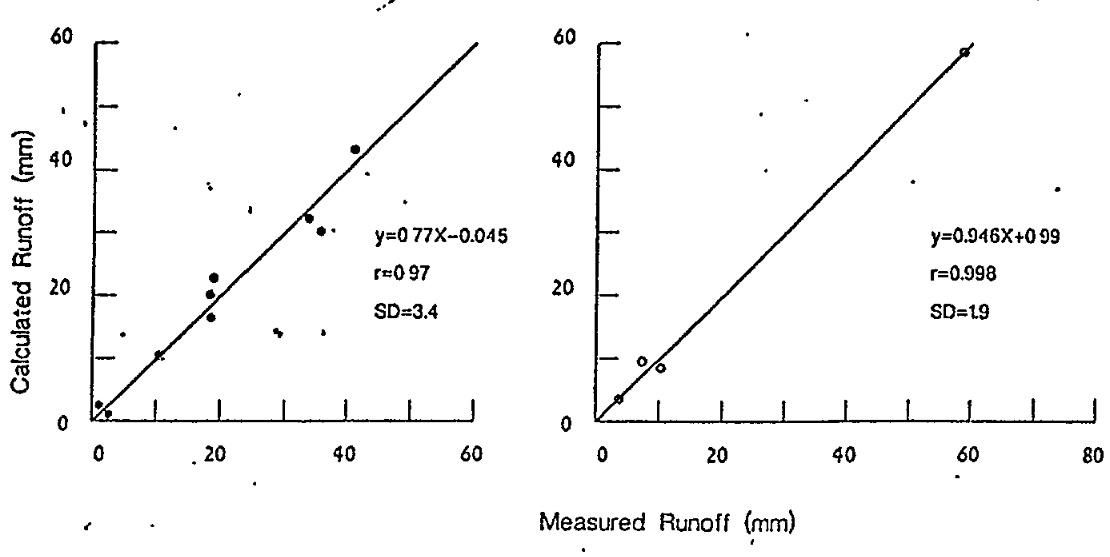


Fig.7a Predicted and measured runoff in wheatfields on Calcic Luvisol soil

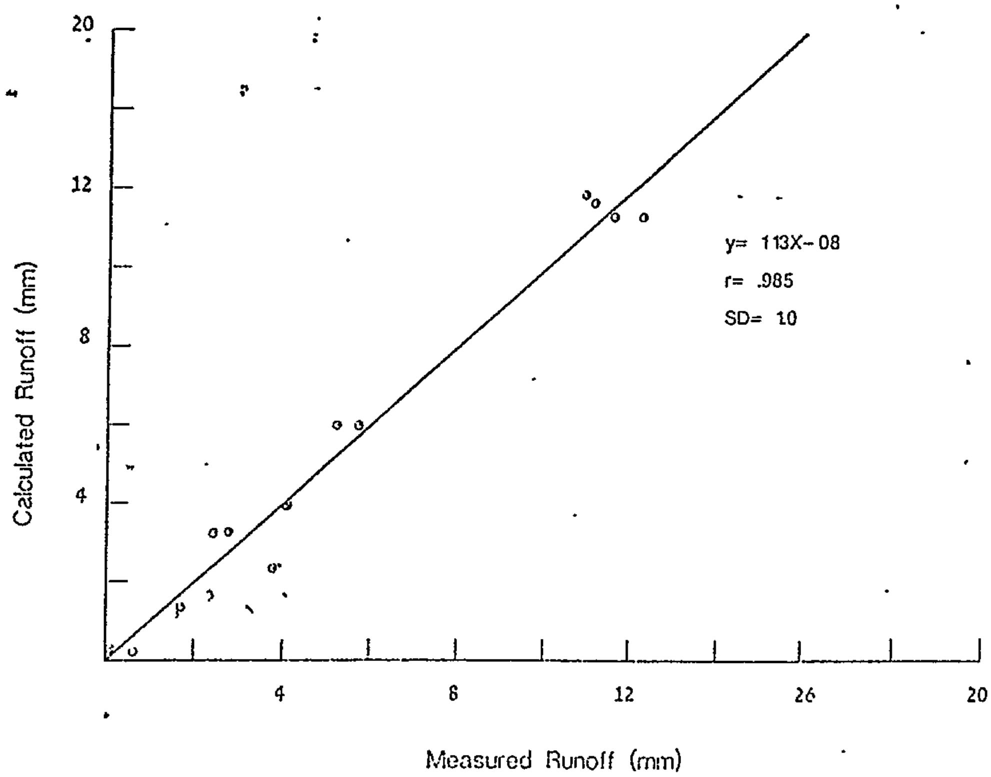


Fig.7b Predicted and measured runoff in cotton fields on Vertic Luvisol soil.

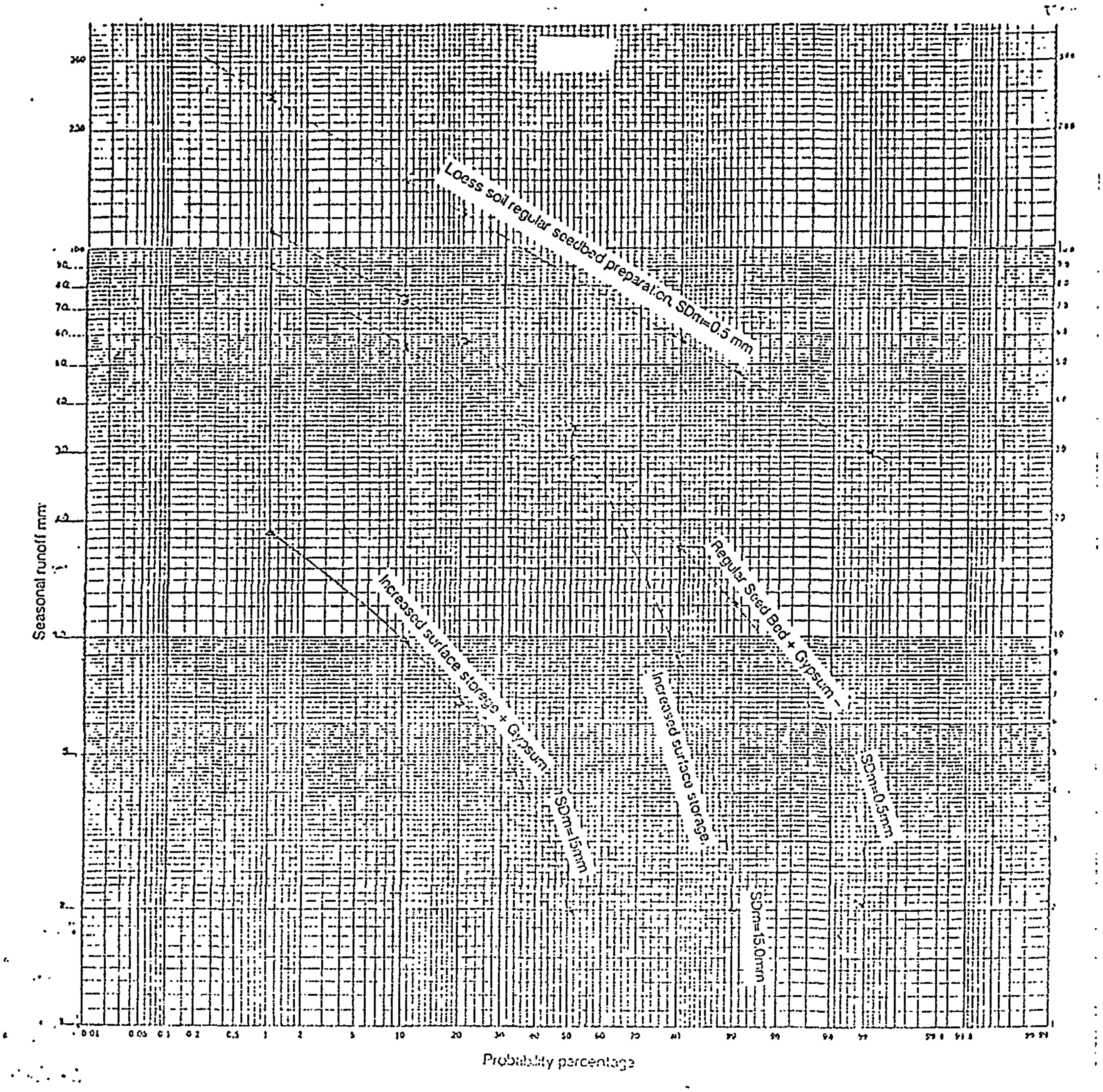


Fig.8 Probability analysis of runoff for management evaluation in Calcic Luvisol soil near Gaza.

The crust formation is influenced by the chemical and physical properties of the soil and the rain. Among the significant soil properties are: soil aggregate stability, aggregate size distribution, hydraulic and conductivity and matric potential.

The physical and hydraulic properties of the soil surface are changed by the drop impact (Falayi and Bouma, 1975). These changes are related to the aggregate stability (Rawitz and Hazan, 1978; De Boodt et al., 1961), the cumulative rain applied to the soil surface (Morin and Benyamini, 1977; Dexter et al., 1983), and the kinetic energy of raindrops (Eigel and Moor, 1983; Wustamidin and Douglas, 1985).

The basic concept in the rainfall - runoff relationship is the relation described by equation 16:

$$P = I + R \qquad (16)$$

when:
P - Rainfall (mm)
I - Infiltration (mm)
R - Runoff (mm)

3.2 Infiltration and soil crusting

Duley (1939) reported on the formation of a thin compact layer at the surface of a bare soil subjected to rainfall. This layer was approximately 0.3 in. thick, which significantly reduced infiltration. When the soil surface of a sandy loam-soil was mulched, an intake rate of 1.2 in./h was measured compared to 0.25 in./h in an unprotected soil. Duley suggested that the compacted layer is a result of packing fine particles around larger ones at the soil surface.

McIntyre (1958) identified surface sealing caused by raindrop compaction and by the washing of the fine particles into the soil matrix. Permeability of the seal and crust layers were several orders of magnitude lower than the underlying soil. The seal layer was about 0.1 mm thick and the crust (the washed-in layer) was about 1.5 to 2.5 mm thick.

Models of water infiltration into surface sealed soils were developed by Hillel and Gardner (1969), Ahuja (1973) and Moor (1981). They assumed that crust hydraulic conductivity is a constant factor.

The prediction of the infiltration process has been described by numerous equations. Horton (1940) proposed an equation (17) which describes a vertical infiltration, and also related it to changes of soil surface characteristics under rain conditions.

$$i = ik + (i_o - i_k)\, e^{-ct} \qquad (17)$$

when:
i_o - initial infiltration rate (mm/h)
t - time from the beginning of the rain (min)
c - factor of the soil

Tackett and Pearson (1965) studied soil crusts formed by simulated rainfall on a sandy loam and on reconstituted soils. The crusts were extremely dense and varied from 1 to 5 mm thick. They observed a thin skin of well-orientated clay at the immediate soil surface. The underlying soils were about five times more permeable than the crust layer.

Mannering (1967) applied simulated rainfall to 60 Indiana soils. Infiltration rates into unprotected bare soils exhibited a marked reduction. Medium textured soils were most seriously affected by the raindrops' impact. Infiltration rates of the unprotected soils were as low as 1/5 of the protected soils. The influence of surface seal of bare soils was established during the initial hour of rainfall. Soil texture was a major factor in determining infiltration rates for bare soils.

Edwards and Larson (1969) reported numerical solutions of the flow equations for a homogeneous soil with a developing surface seal. They conducted rainfall simulator experiments on Ida Silt Loam. The saturated conductivity was expressed as an exponential function of the exposure time of bare soil to simulated rainfall. They found major crusting effects occurring in the first hour. The suction gradient through the crust appears to increase with decreased hydraulic gradient. Thus, the infiltration rate through a soil crust is not a unique factor dependent on the conductivity of the crust.

A model which takes into consideration the influence of raindrop impact on the soil surface was proposed by Seginer and Morin (1970) (equation 18) and was developed into a working equation (19) by Morin and Benyamini (1977):

$$it = ii \cdot \sigma p + (1 - \sigma p) \cdot [e^{-\gamma pt}(ii - if) + if] \qquad (18)$$

when:
ii - initial infiltration rate (mm/h)
if - final infiltration rate (mm/h)
r - factor, represents aggregates stability at the soil surface (1/mm)
p - rainfall intensity (mm/h)

- factor, represents the influence of a drop impact that temporarily breaks the crust and increases the infiltration rate for a unit of time (h/mm).

This model is based on the influence of the impact of a drop on the soil surface to form a crust under bare soil conditions. The model assumed that the impact of a certain drop changes an elementary soil surface unit with an initial hydraulic conductivity into a state of a low final hydraulic conductivity. This model was tested under laboratory conditions with a rainfall simulator by Morin <u>et al.</u>, (1968) and by Seginer and Morin (1970). The derived working equation is as follows:

$$it = (ii - if) \cdot e^{-\gamma pt} + if \qquad (19)$$

(see terms in equation 18)

The equation is similar to the "Horton equation" (17) by its form; however, in this equation the rain intensity value "p" is added and the factors have physical meanings.

The use of equation (19) for different soils and conditions allows us to solve the necessary parameters, and to use them to predict the infiltration process under various conditions.

The experiments conducted by Morin et al., (1968) after Burst (1942) and Hudson (1957) also proved that the main factor in crust formation is the drop impact under bare soil conditions.

The kinetic energy ($1/2mv^2$) of the rainfall is a parameter which is characteristic of a specific rainfall pattern. The physical expression of the raindrop impact is its kinetic energy. Chen et al, (1980) under scanner electronic microscopic tests, proposed two stages in crust formation which agreed with other publications: (a) fine particles are detached from coarse particles, (b) the fine particles migrate and reorganise into a thin layer of 0.1 mm on the soil surface. This mechanism is in agreement with the dynamic mechanism proposed by Morin et al, (1981), which stated that the downward flow due to the under crust section enhances the organisation of the crust layer. Morin et al., show that the effect of the depth of wetting on the rate of crust formation is very limited.

The rainfall amount needed to form a crust, depends also on aggregate, size and their stability (Gumbs and Warkentin, 1976). Small aggregates are more stable than large ones. However, more energy is needed to break down large aggregates (Moldenhaouer, 1970).

Tillage practices result in different aggregate size distributions (Hadas et al., 1978; Benyamini, 1981; Dexter et al., 1983; Unger, 1984), which in turn are affected by the soil type, the implement, and the moisture content at the time of the soil cultivation (Armburst et al., 1982). Stable aggregates and high value of roughness (Allmaras et al., 1977; Linden, 1979) results in higher infiltration values.

Agriculture tillage can significantly alter the surface roughness and the total porosity of the surface and underlying layers. Tillage alters their susceptibility to natural forces forming surface crusts. The tillage might change the rate of crust formation, but the final infiltration rates after few storms are very similar for the different tillage operations.

4. THE EFFECT OF SOME CHEMICAL PROPERTIES OF THE SOIL ON WATER INTAKE

4.1 The effect of soil sodicity and water salinity on the hydraulic conductivity of soils

The effect of the electrolyte conductivity (EC) of the percolating water and the valency of the cations on the hydraulic conductivity (HC) of soils was studied by many workers (Quirk and Schofield, 1955; McNeal et al., 1966, 1968; Yaron and Thomas, 1968; Frenkel et al., 1978, Cass and Sumner, 1982 a,b; Rhoades and Ingvalson, 1969; Felhendler et al., 1974; Shainberg et al., 1981 a,b). The HC of soils increases with the increase of the absorbed CA cations percentage and increases with the increase in the EC of the percolating water. These phenomena are explained by the diffuse double layer theory (Bolt, 1979; Bresler et al. 1982, Shainberg et al., 1978; Van Olphen, 1977; Warkenstein et al., 1957). The repulsion forces between two neighbouring clay platelets decrease with the increase in the salt concentration of the soil solution and with the increase in the valency of the absorbed cations. Thus the distance between the platelets is smaller and the tactoids are more compact and more resistant to swelling by the percolating water (Blackmore and Miller, 1961).

When the exchangeable Sodium percentage (ESP) of the soil increases and the salt concentration of the percolating water decreases, the tactoids will be less resistant to swelling pressure and the HC of the soil decreases.

This phenomenon is shown in Fig.9. It is obvious that the HC of the soil decreases with the decrease in the soil solution salt concentration and with the increase in the Sodium absorption ratio (SAR) of the percolating water. By increasing the SAR of the percolating water, the ESP of the soil increases too.

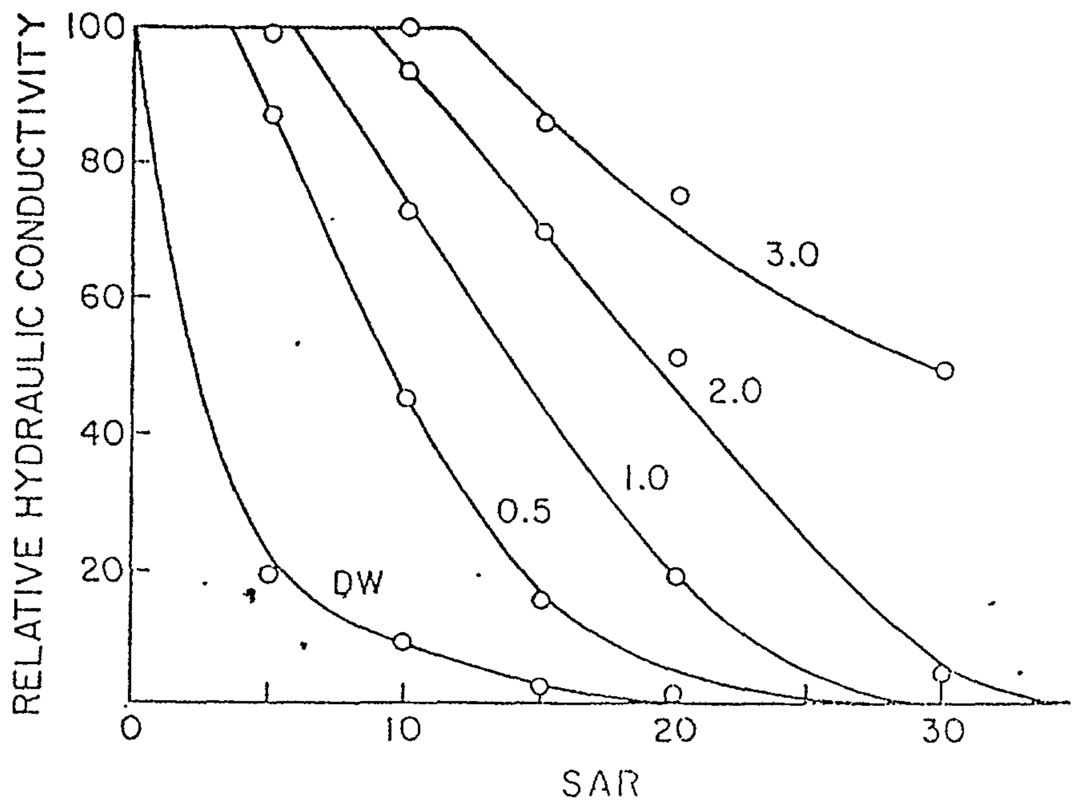


Fig.9 Effects on fallbrook soil-sand mixture's HC of the ESP of distilled water 9DW0 and various soil solution salt concentrations.

4.2 The effect of soil sodicity and water salinity on the infiltration rate of water into soil

Infiltration or intake of water into the soil is one of the more important processes in the soil phase of the hydrological cycle. The rate of the infiltration (IR) process compared to the rate of water supply, determines how much water will enter the soil and how much will run off. The amount of overland water runoff determines the amount of soil erosion.

The IR is defined as the volume of water flowing into the profile per unit surface area of soil. This flux has the dimension of velocity. The initial infiltration capacity is generally high but it tends to decrease gradually until reaching a constant rate - the final infiltration rate or steady state IR. The decrease in infiltration capacity of a soil mainly results from a gradual deterioration of the soil surface structure and the formation of a surface crust.

It is evident that crust formation is associated with clay dispersion and movement in the soil. When crusting processes are taking place, soil surfaces are especially susceptible to the chemistry (electrolyte concentration and cationic composition) of the applied water because of the mechanical action of the falling drops and the relative freedom of particle movement at the soil surface. Oster and Schroer (1979), studying the IR of undisturbed loam soil columns, found that the effects of the applied water chemistry were far greater than expected. When the ESP of the surface layer was 8, the IR decreased from 15 to 1 millimetre per hour (mm/h) as the concentration of the irrigation water decreased from 28 to 8 meq/l. Comparable reduction in saturated hydraulic conductivity of saturated soils having an ESP of 10 occur only when the concentration of the percolating solution decreases below 2-3 meq/l (Shainberg et al., 1981a).

The effect of soil sodicity (ESP) and water salinity on the IR and crust formation in three soils varying in their texture and structure was studied by Agassi et al., (1981). It was found (Figs. 10, 11 and 12) that the IR of the soils is very sensitive to the soils' ESP, especially when distilled water (DW) was used. In the Chromic Luvisol soil (Fig.12) with ESP 1.0, the IR drops from initial value of over 100 mm/h to about 7.5 mm/h. In the Calcic and Vertic soils with ESP 2.5 it drops from 45 to about 3.0 mm/h (Figs. 10,11). The effect of water salinity and soil ESP on the final infiltration rate (FIR) is summarised in Fig.13.

The rate of the IR decrease accelerates with reduced electrolyte concentration. Similarly at the same electrolyte concentration, the higher the sodicity of the soil, the greater is the rate at which the IR drops to its final value, and thus its final value is lower. It was concluded (Agassi et al., 1981) that crust formation is a kinetic process which depends on the electrolyte concentration in the applied water, the ESP of the soil and the disturbance caused by applied water at the soil surface.

The rate of chemical dispersion is worth re-emphasising. When solutions of high concentration are applied, the impact energy of the drops is the main force causing the breakdown of the soil aggregates and a compacted layer with low permeability is produced at the soil surface. The rate at which this compacted layer is formed is relatively slow, and the final IR values are maintained at 8 to 15 mm/h. When low-salinity water is applied to the soil, even with low levels of exchangeable sodium, chemical dispersion of the soil clays also occurs. The dispersed clay particles can be washed into the soil with the infiltrating water, and the pores immediately beneath the surface become clogged (Gal et al., 1984).

The effect of water drop impact energy and water salinity on the infiltration rate (IR) of two sodic soils: Calcic and Vertic Luvisol, was studied by Agassi et al. (1985) using a rainfall simulation. Rain with kinetic energy of 22.9 $j/mm.m^3$ (similar to the energy of natural rainstorms (Morin et al., 1967) and a low energy, with kinetic energy less than 0.01 $j/mm.m^2$. In the low energy rain (Fig.14) the initial IR of the soils (44 mm/h) was maintained during a distilled water rain on soils with ESP 2.5, and during saline water rain on soils with ESP values of 6.5 and 17-21.0 mm/h. In Calcic Luvisols with ESP values of 6.5 and 21.0 the final IR (FIR) under low energy rain dropped to 28.8 and 11.5 mm/h respectively. When the same soil and ESP levels were subjected to high energy rain, the FIR during saline water storms dropped to 6-9 mm/h and during distilled water simulated storms the FIR dropped to 0.9-1.4 mm/h. It was concluded that both the water drop impact energy and electrolyte concentration in the applied rain have a decisive effect on the IR drop of soils.

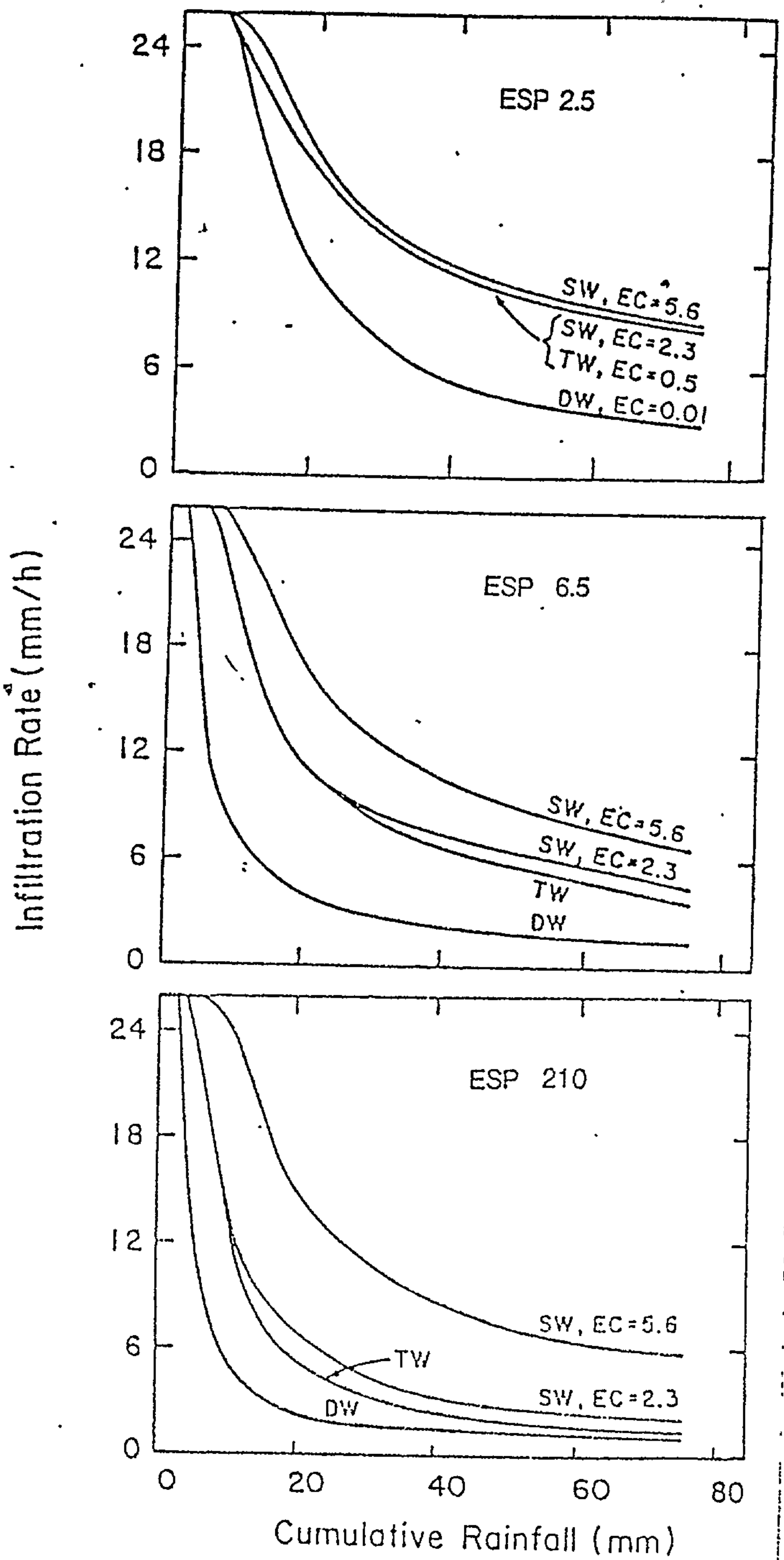


Fig.10 Effect of electrolyte concentration in rain simulation experiments on the infiltration rate of calcic luvisol soil.

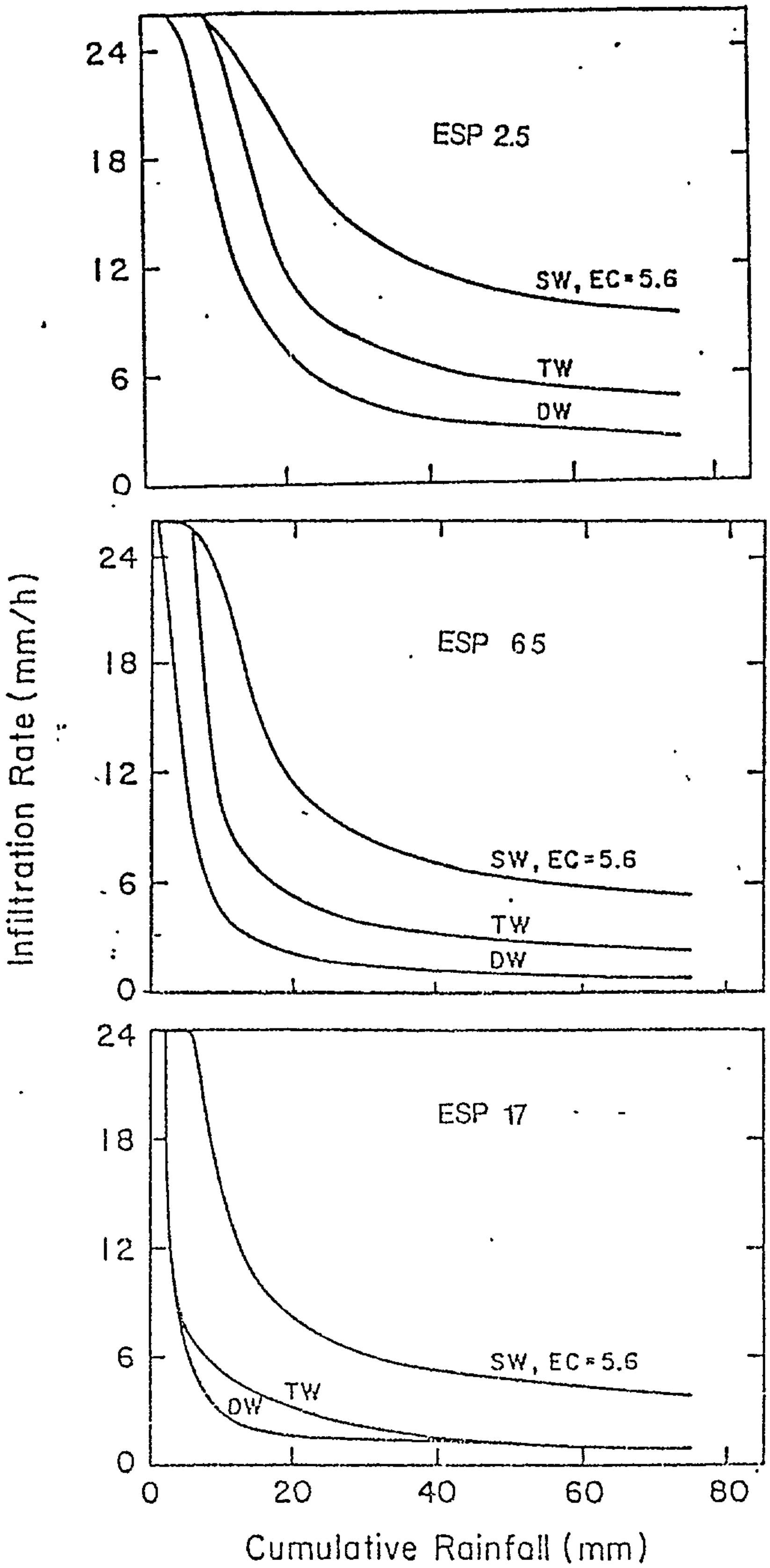


Fig.11 Effect of electrolyte concentration in rain simulation experiments on the infiltration rate of vertic luvisol soil.

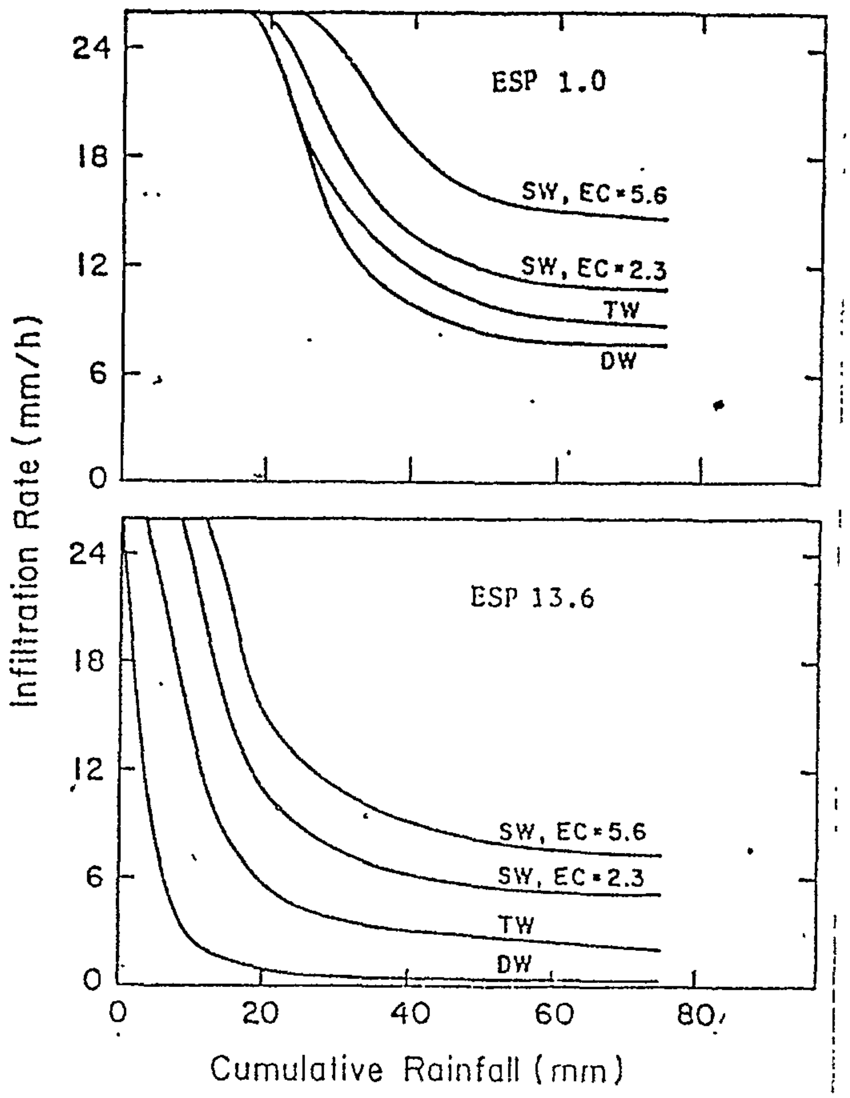


Fig.12 Effect of electrolyte concentration in rain simulation experiments on the infiltration rate of chromic luvisol soil.

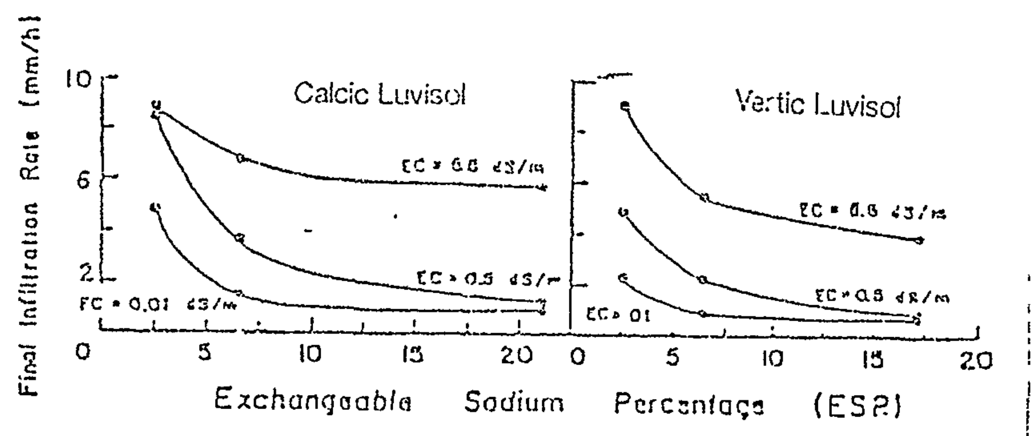


Fig.13 Effect of ESP and electrolyte concentration on the final infiltration rate (FIR) of the calcic and vertic luvisol exposed to high-energy rain.

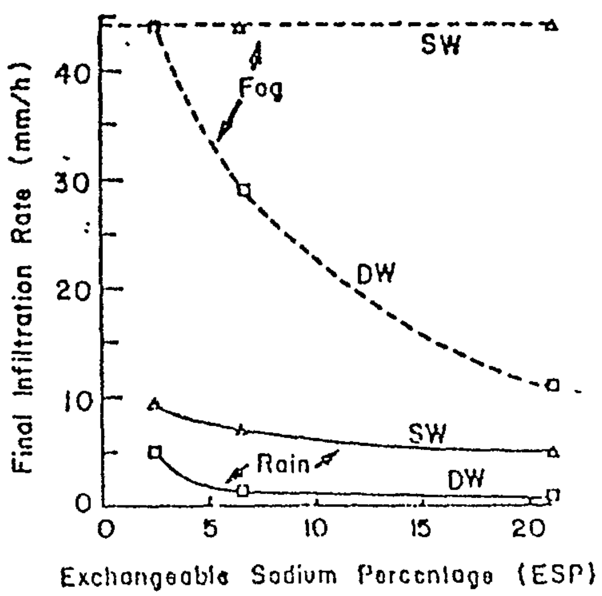


Fig.14 Final infiltration rate (FIR) of calcic luvisol as a function of the soil ESP, water salinity, and impact energy of the rain.

When the chemical dispersion processes are minimal (low ESP and high water salinity), the mechanical impact of the drops predominate and the crust formation is mainly due to the disintegration of soil aggregates and their compaction to a thin skin seal. When the soil ESP is high (2.5) and the water salinity is low (rainwater), chemical dispersion processes have an increasing role to play in determining the IR of the soils.

The effect of rainfall energy, water salinity and soil sodicity on crust reversibility was studied by Agassi et al. (1987) on silty loam soil (Calcic Luvisol) with medium (9.0) and low (2.5) exchangeable sodium percent values, using a rainfall simulator. Saline water (EC = 5.6 ds/m) and distilled water were simulated at two energy levels: high energy, with kinetic energy of 22.9 Joules/mm.m^2 and low energy, with kinetic energy of 0.01 Joules/mm.m^2. Rainfall energy and water salinity were changed during continuous storms, once at the beginning of the experiment and in other experiments at its end, when FIR was achieved. The effect of these changes on infiltration rate and crust reversibility are as follows. Crust formed by raindrop impact of saline or distilled water was found to be irreversible when high energy rainfall was changed into low energy rainfall. Changing high energy rain of distilled water into low energy rain of saline water at the end of the experiment was not followed by an increase in infiltration rate.

Crust formed by high energy or low energy rain of distilled water was found to be reversible to some extent when the salinity of the rainwater was increased. The reversibility occurred to a larger extent as the ESP of the soil decreased and when the change of the salinity of the rainwater took place at the beginning of the experiment.

These findings are important for semi-arid and arid regions where intermittent application of saline irrigation water with relatively low impact energy occurs simultaneously with natural rainfall.

5. DESCRIPTION OF THE LAND AT THE EXPERIMENTAL SITES

In Table IV the properties of the soils are presented. The soils at the experimental sites were divided into three units:

(i) The loessial soils, calcic Luvisols (LK) of Nahal Oz, Alumim Shoval and Dvir (Table IV, sites 1-5) are located on gently rolling lands with slopes ranging from 3 to 6%. They consist of holocenic, calcareous, aeolian sediments (loess), which were deposited on brown to reddish brown clay-loams of the pleistocene age. The texture of the loessial upper layer is silt and its colour, yellowish light brown. The thickness of this layer varies between 30-60 cm according to the conditions of erosion.

The annual rainfall in the area is 300-350 mm with a coefficient variation of 0.35. At Shoval the average is only 275 mm with C.V. of 0.38.

The area has been under cultivation for thousands of years, so the natural vegetation has been thoroughly destroyed, though clearly it was once a steppe vegetation. Of the segetal vegetation "Cynodon dactylon" should be mentioned, because of its persistence and its detrimental influence on crops.

The land use at the different sites is as follows:

- Nahal Oz, sites 1 and 2 : rainfed wheat and legumes with occasional fallow;
- Alumim, site 3 : irrigated cotton and supplementary irrigated wheat;
- Shoval, site 4 : supplementary irrigated wheat and legumes with occasional fallow;
- Dvir, site 5 : rainfed wheat and legumes with occasional fallow.

(ii) The Vertisols of Kedma and Kfar Menahem (LV to Vc) cover the rolling hills of a disected plateau. The upper layer, where not eroded, is a brown, calcareous clay-loam 20-40 cm thick. Below it lies a brown to reddish brown clay up to a depth of a few metres, where rather high amounts of absorbed sodium is found. This sub-layer cracks extensively. Where the upper layer is in place, the soil is a vertic Luvisol (Lv). Where it is eroded the soil is a chromic Vertisol (Vc), high in exchangeable sodium. There is also a transition, where the two layers get mixed by geoturbation or deep ploughing. This area has been cultivated for a very long time. It may have been a park landscape or a low forest with Quercus calliprinus as one of the important elements. Of the segetal weeds of today, Prosopis farcata may be mentioned. The average annual rainfall in the area is about 450 mm with a coefficient of variation of 0.33.

The land use at Kedma, sites 6 and 7, is rainfed wheat with occasional fallow or summer crops (sorghum or sunflowers) in rainy years with good moisture penetration.

Kedma, sites 8 and 9, where wheat was grown, but in the year before the onset of the experiments, irrigation was installed and cotton was sown, but with very poor results because of sodicity.

Kefar Menahem, sites 10 and 11: Wheat with occasional summer crop like plots 6 and 7.

Table IV

Some chemical and physical properties of the soil from the experimental sites

Soil and site number	Soil units	Slope %	Mechanical analysis %			Saturated paste		CEC m.eq/100g	ESP %	$CaCO_3$ %
			Sand	Silt	Clay	Water content %	EC ds/m			
1. Loess, Nahal-oz	LK - Calcic Luvisol	2	48.5	31.5	20.0	42.0	2.70	15.0	6.5	11.7
2. Loess, Nahal-oz	LK - Calcic Luvisol	2	49.6	25.6	24.8	50.0	4.30	17.5	21.0	8.9
3. Loess, Alumim	LK - Calcic Luvisol	2	46.8	35.7	17.4	49.1	1.44	15.5	2.5	10.8
4. Loess, Shoval	LK - Calcic Luvisol	4	34.0	40.0	26.0	60.0	0.40	17.7	1.6	18.0
5. Loess, Dvir	LK - Calcic Luvisol	7	37.2	36.2	24.6	50.3	1.13	17.1	3.0	18.3
6. Vertisol, Kedma	LV - Vertic Luvisol	3	27.9	24.2	47.9	65.0	0.60	40.5	3.0	11.0
7. Vertisol, Kedma	to VC - Chromic Vertisol	7	18.8	30.8	50.4	75.0	1.20	43.5	7.0	16.4
8. Vertisol, Kedma	according to extent	7	15.2	32.4	52.4	80.0	2.00	44.1	17.0	9.7
9. Vertisol, Kedma	of erosion	7	21.7	25.4	52.9	75.0	0.95	39.4	13.0	10.4
10. Vertisol, K. Menahem		8	31.0	21.8	47.2	82.0	1.93	44.1	13.8	15.4
11. Vertisol, K. Menahem		8	28.5	22.3	50.2	85.0	2.11	51.5	23.9	15.4
12. Hamra (Sandy loam) Natania	LC - Chromic Luvisol	7	79.0	10.0	11.0	28.0	1.00	8.0	1.0	0.2
13. Hamra (Sandy loam) Nir-Eliahu	LC - Chromic Luvisol							5.0	2.0	0.1

(iii) The sandy loam soils of the Natanya (site 12) and the Nir Eliyahu (site 13) have been developed on old pleistocene sand dunes. These are chromic Luvisols (Lc) with a textural illuviated B horizon. The A horizon is a light brown loamy sand, 40-50 cm thick, if not truncated by erosion. The B horizon is red sandy loam to sandy clay-loam which reaches a depth of about 2 m. The C horizon is yellow sand. The whole profile is devoid of time.

The area has been under cultivation for some 100 years. It was apparently occupied by a forest of Quercus ithaburensis, which was destroyed a long time ago. Before the beginning of the cultivation, it was grassland with Eragrostis bipinnata as the leading grass. The average yearly precipitation is somewhat less than 600 mm with a C.V. of 0.23.

Present land use:

Site 12 (Natanya) belongs to the Experimental Station for Erosion Research and has no permanent agricultural use.

Site 13 (Nir Eliyahu) is in a rotation with potatoes and peanuts as the main crops.

In Fig.15, the location of the different sites is presented on the map of Israel.

6. THE EFFECT OF SOME AGROTECHNICAL METHODS ON RUNOFF AND EROSION IN SEMI-ARID REGIONS OF ISRAEL

6.1 Rainfall simulator use in Israel

Rainfall simulation, the technique of applying water to plots in a manner similar to natural rainfall, is a tool that has been used for many years in studies of erosion, infiltration and runoff.

The rainfall simulator which is in use in Israel is the "rotating disk type" (Morin et al., 1967; Morin and Cluff, 1980), which simulates the natural rain by its drop size distribution, its rate and its kinetic energy. There are two different units of the same rainfall simulator type. One is located in the laboratory and the second is a portable field unit. The measurements which are obtained from the rainfall simulator are the infiltration rates in the laboratory unit and runoff rates in the field unit.

The analysis of the results has been done by using the infiltration equation (19). The parameters obtained from the solution of the equation for different soil conditions (different tillage methods, water content, soil type, etc.), enable us to predict the behaviour of bars soils under natural rains.

In order to obtain working values of the above parameters, we further use different scales of plots: small plots in the laboratory (boxes of 30 x 50 x 10 cm) and medium size plots in the field (1.5 m^2). For natural rains, in the field, we use medium size plots of 6 x 25 m and large plots of 9 x 100 m.

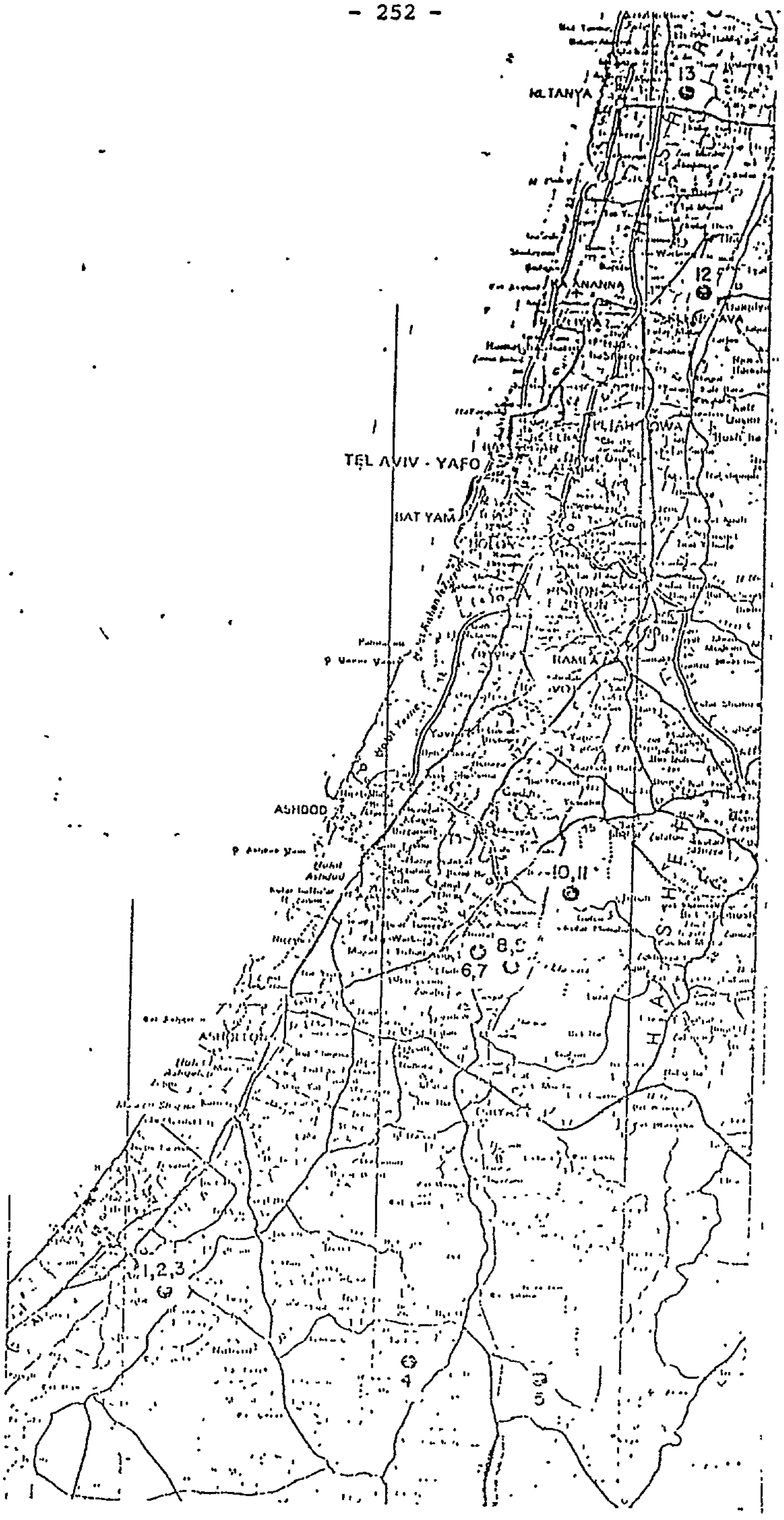


Fig.15 Location of experimental plots

6.2 Rainfall simulators studies (field plots)

A field study was conducted in Lachish Farm in the southern part of Israel. The soil was Calcic Luvisol with 34% silt, 34% clay, and 32% sand. Different tillage methods and their influence on the overland runoff was studied. The rainfall simulator was used to apply 56.0 mm/h of simulated rainfall until the final infiltration rate was achieved. Plots of 1.5 m^2 were installed with 3 replications for each treatment.

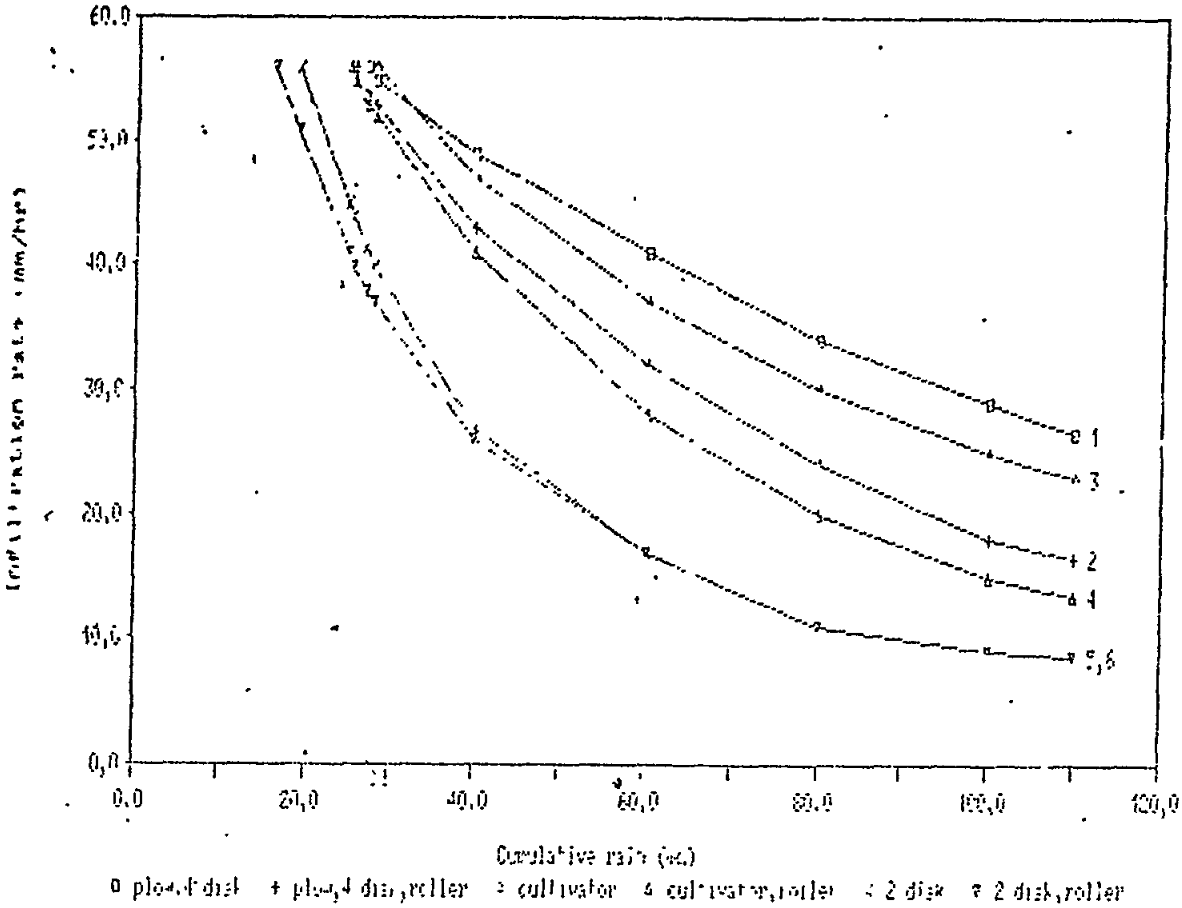


Fig.16 Infiltration rate as a function of cumulative rain for 6 tillage operations.

The different tillage methods were:

(i) the field was ploughed and then disked 4 times
(ii) the field was ploughed, disked 4 times and then rolled with a roller
(iii) the field was tilled by a cultivator
(iv) the field was tilled by a cultivator and then rolled with a roller
(v) the field was tilled with a disk 2 times
(vi) the field was tilled with a disk 2 times and then rolled.

The tillage operations gave different aggregate size distribution in the soil surface as shown in Fig.17. Final infiltration rate was higher for the tillage operations which gave larger aggregate size at the soil surface.

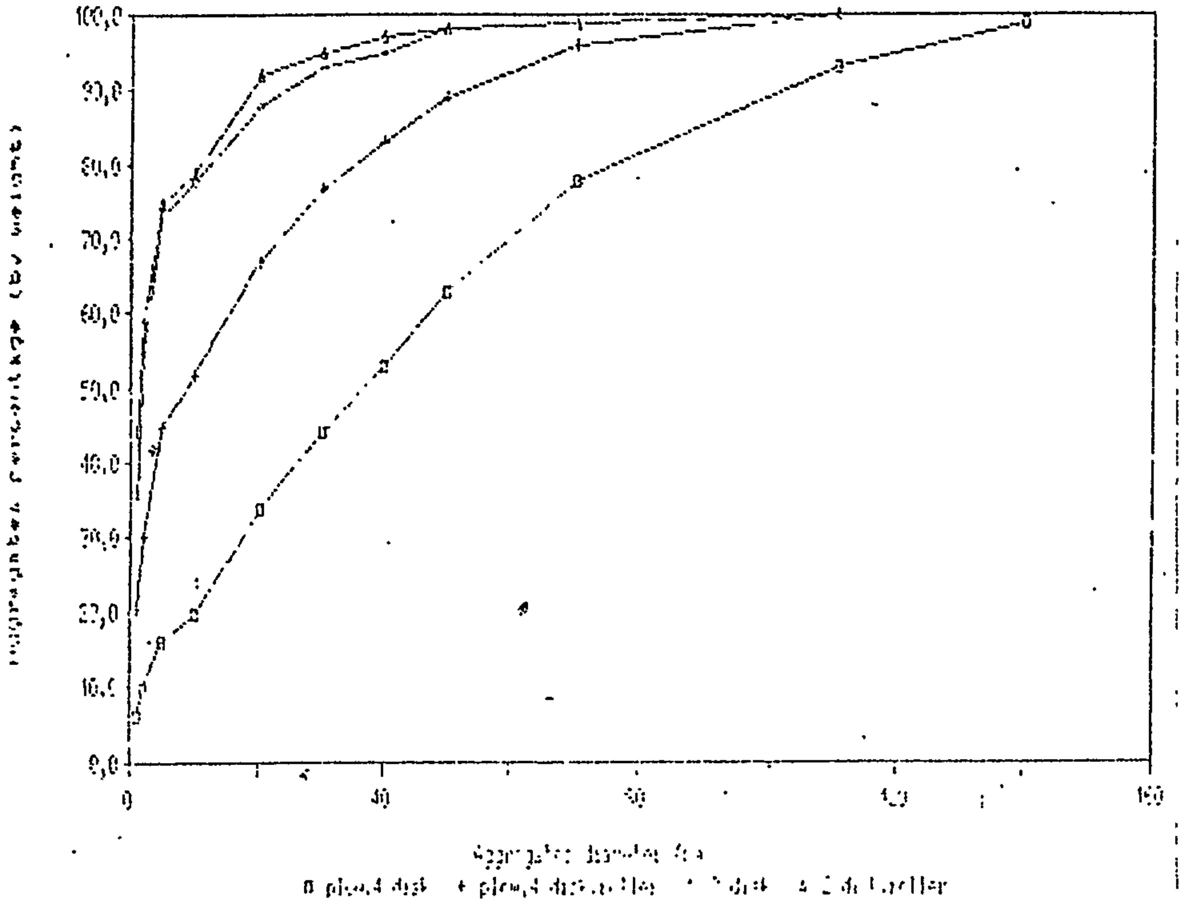


Fig.17 Aggregates size distribution for 4 tillage operations.

The cumulative infiltrated rain for the different tillage methods are shown in Fig.18. When the soil aggregate size was larger, the cumulative infiltration was higher. Reduction in the surface roughness decreased the amount of the infiltrated water for the same amount of rain.

A second rain, after different periods of drying (1, 3, 6, 7 or 10 days), was applied upon the crusted soils. It was found that the amount of rain which was needed to achieve the final infiltration rates was smaller in the second rain and that the period of drying between rains was shorter.

The parameters of equation (19) for the above tillage operations are presented in Table V. By these parameters we can predict runoff from fields under natural rains, under the same conditions (see section 2).

The linear regression coefficient between the measured and calculated infiltration rates by equation 19, were 0.80 to 0.99.

Studies similar to the one described above were conducted in other sites throughout Israel. Each site was chosen in order to define different types of soils with various conditions.

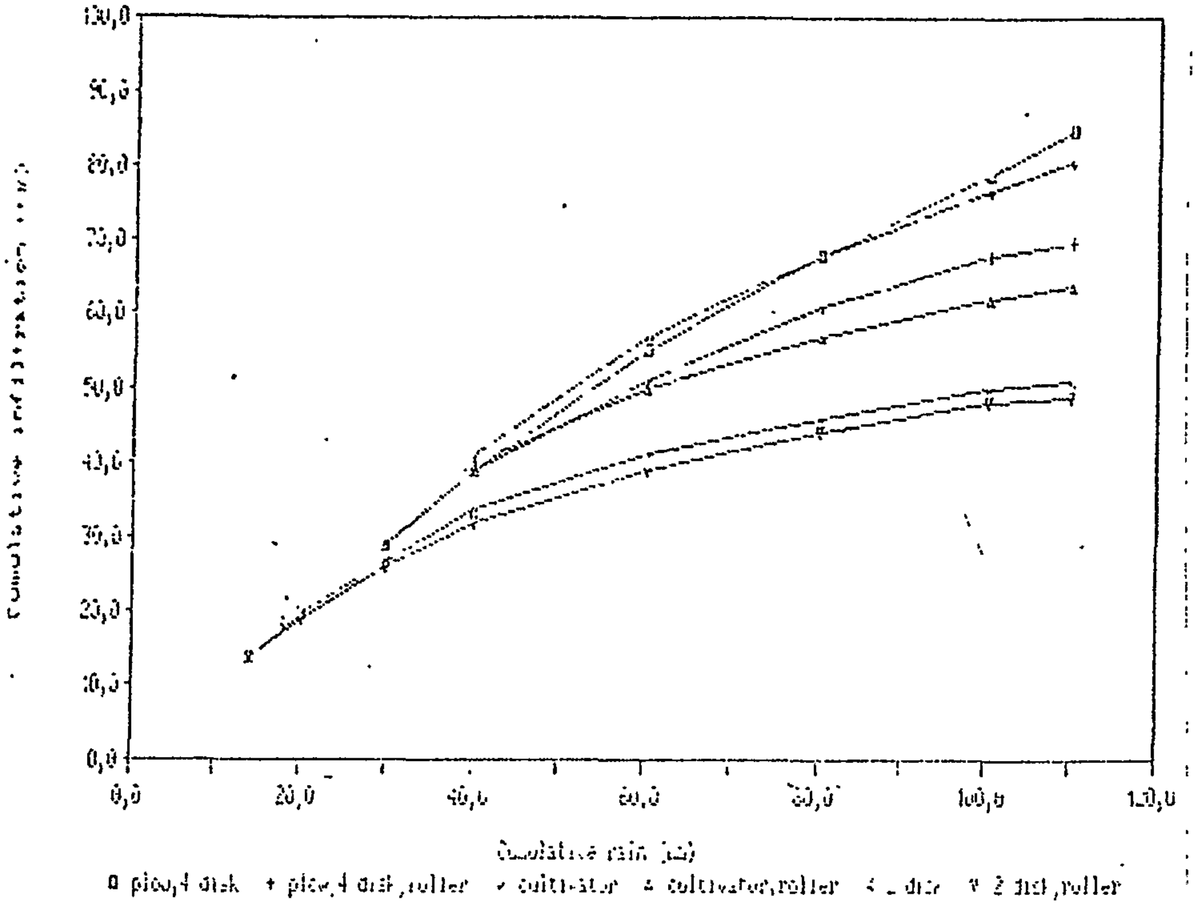


Fig.18 Cumulative infiltration as a function of cumulative rain for 6 tillage operations.

5.3 <u>Field plots (natural rain)</u>

In order to verify the results reached in small field plots, which were rained with rainfall simulator, similar experiments were conducted on large plots in commercial fields, subjected to natural rainstorms.

It was emphasised in Section 2 that, by increasing the soil surface storage, the surface runoff decreased considerably. In rowcrops and even in wheat fields it is possible to increase the soil surface storage by constructing dyked furrows in the field (basin listing, basin tillage - Unger, 1984).

A three-year experiment was set up in Alumim, in the southern part of Israel, in order to study the efficiency of the dyked furrows method in comparison with tillage methods common in this region (Rawitz <u>et</u> <u>al.</u>, 1983; Morin <u>et</u> <u>al.</u>, 1984 (a,b); Morin <u>et</u> <u>al.</u>, 1985).

The experimental plots were 25 x 6 m, with a 3-4% slope. The runoff and the erosion were collected in a set of barrels, three in a series for each plot. Each barrel collected 10% of the previous one. The experiments were divided into two sections: (a) autumn cultivation for spring cotton, and (b) autumn cultivation for the winter wheat seedbed.

Table V

The field parameters achieved by the experiment

Treatments	Initial inf. rate mm/h	final inf. rate mm/h	r 1/h	Drying time days
1. Disk 2 times	113.4	6.9	0.041	1 st *
2. Disk 2 times, roll	95.5	7.4	0.039	1 st
3. Disk 2 times, roll	52.1	5.6	0.092	3
4. Disk 2 times, roll	85.7	6.3	0.052	10
5. Plough, disk 4 times	72.7	10.0	0.012	1 st
6. Plough, disk 4 times	59.2	6.0	0.047	3
7. Plough, disk 4 times	73.8	6.0	0.033	10
8. Plough, disk 4 times	87.6	8.0	0.020	1 st
9. Cultivator	82.3	12.8	0.017	1 st
10. Cultivator, roll	96.9	8.5	0.025	1 st
11. Cultivator, roll	71.5	4.2	0.060	3
12. Cultivator, roll	48.9	4.2	0.038	10

* first rain on fresh cultivated area

The following fall tillage treatments for cotton were carried out in three replications on deep-ploughed soil:

(i) deep ploughed (control)

(ii) disking and rolling with a scalloped cultipacker

(iii) disking and ridging with a disk furrower

(iv) dyked furrows: disking and ridging as in treatment 3 and constructing earth dykes in the furrows of 100 cm distance

The following fall treatments in three replications, for winter wheat were:

(i) heavy disk, cultipacker, and sowing with a grain drill (control)

(ii) the same cultivation as in treatment 1, followed by construction of 0.6 m wide beds, together with the construction of earth dykes in the furrows and seeding with a drill (basin tillage)

(iii) the same cultivation as in treatment 2 but with 1.6 m wide beds (basin tillage)

(iv) the same cultivation as in treatment 2 and left fallow (no seeding)

Treatment 1 was the control, representing current practice. Treatment 4 represents the influence of seeding by a drill on the dyked furrows storage. The plots of treatment 2 had a surface storage capacity of 15 mm, which decreased to 8-10 mm after seeding with the drill. Sowing was done with a John Deere disk drill with an 11 cm row spacing, which sowed in the basins as well. Rainfall was recorded by a rain gauge and by an adjacent integrating miniature rain gauge. The results of the cotton plots for selected storms in the 1979-80 winter are presented in Table VI.

Table VI

Comparison of runoff observed from the control plots with the basins tillage plots

Date of storm	Rainfall (mm)	Measured runoff from control plots (mm)	Measured runoff from control plots (mm)
29.11.79	63	20	1
06.12.79	42	19	3
14.12.79	52	35	1
27.12.79	66	20	4
07.01.80	67	35	4
23.01.80	89	44	4
10.02.80	12	7	2
15.02.80	45	9	2
25.02.80	25	5	2
29.02.80	55	30	2
Total	516	224	28

The dyked-furrow treatment showed the lowest runoff among the tested tillage methods and seems to be the most promising one. The results for the wheat experiments are presented in Table VII.

Table VII

Runoff and erosion from the wheat experiments, Winter 1980-81

Treatment	Storm of 10.12.80 (rainfall = 64mm)		Storm of 11.01.81 (rainfall = 34.6mm)		Seasonal total	
	Runoff (mm)	Erosion (Kg/ha)	Runoff (mm)	Erosion Kg/ha	Runoff (mm)	Erosion Kg/ha
Control	14.3±0.8	228±30	3.5±0.03	65±9	17.7	293
Fallow plots	15.0±0.7	301±52	6.6±0.1	96±32	21.6	397
1.6 m-wide Beds	6.7±0.8	120±15	1.2±0.3	36±11	7.9	156
0.6 m-wide Beds	6.5±0.9	145±25	0.9±0.4	27±20	7.4	72

The wheat yields of the different treatments are presented in Table VIII.

Table VIII

The effect of surface configuration on wheat yield (Kg/ha)

Treatment	Replication			Average	F test (compared with the control)
	1	2	3		
Control	892	1017	975	975	
Basin tillage 1.6 m - wide bed	1242	1483	1483	1403	22.3 *
Basin tillage 0.6 m - wide bed	808	792	1292	964	0.004 NS

* Significant at the 0.01 level

The rainfall amount of the 1980-81 winter was only 54% of the annual average and produced little runoff even under conventional tillage (control). However, 1.6 m beds basin tillage increased the yield almost to a break-even economic level.

A long-term, large plot experiment was carried out in the Shoval site. Different tillage procedures, aimed at enhancing rainfall infiltration on wheat fields, were studied.

The experiments were carried out in two blocks.

Block A contained 12 plots of 800 m^2 each, with an average slope of 3%. Each plot was bounded by earth levees, and runoff water was measured at the lower end by calibrated discharge-measuring flumes, equipped with water-stage recorders. The tillage treatments were as follows:

(i) control: heavy disk, cultipacker and sowing with a John Deere drill

(ii) gypsum: Phospho-gypsum was applied after sowing as in treatment 1, at a rate of 5 tons/ha (See section 7)

(iii) pitting: pitting and seeding were done together. Pitting was done by special equipment which creates small and dense pits over the soil surface

(iv) basin tillage: wheat seeding with a drill on a flat seed bed, followed by a row-crop basin-lister, with a spacing of 1.6 m between the basin rows, as in Alumim wheat experiment.

Block B consisted of nine plots, similar to Block A, and placed in continuation of Block A, but without the gypsum treatment. The slopes varied from 5% to 9%. These plots were constructed in the 1984-85 winter in order to study the stability of the imposed micro relief under steeper slopes.

Table IX presents a summary of the rain, runoff and wheat grain yield from the four years of experiments.

Table IX

Wheat yield under various tillage treatments in Shoval 1981-82 to 1984-85

Year	Rain + irrigation (mm)	Runoff (control) (mm)	Grain yield (Kg/ha)		
			Control	Pitted	Basin tillage
1980-81	217	17	975	-	1403
1981-82	200+50	20	890	1870	1950
1983-84	143	traces	560	785	-
1984-85	239+50	16	990	1460	1410
1984-85	239 *	16	482	833	

* data from block B, without supplementary irrigation

The additional cost for the pitting tillage, as well as for the basin tillage on wide beds, is equivalent to the value of 50-70 Kg/ha of wheat grain. From Table IX, we can see that even during the drought season of 1983-84, the average yield in the pitting treatment, in comparison to the control, was higher by 225 Kg/ha. The efficiency of the pitting and the basin tillage in increasing the infiltrability of the soil, and reducing land runoff and increasing wheat yield, is obvious.

The machinery for the pitting and the basin tillage is still undergoing improvement in order to increase surface storage and decrease the difficulties of harvesting due to the soil micro-relief.

7. PHOSPHOGYPSUM AS AMENDMENT FOR RUNOFF AND EROSION CONTROL IN SEMI-ARID REGIONS OF ISRAEL

7.1 Laboratory studies

The water added to the soil by rainfall can either infiltrate, accumulate on the soil surface or form surface runoff. Annual rainfall in semi-arid regions is low, uncertain and patchy. Paradoxical as it may sound, however, in spite of the deficiency in rainfall, large amounts of water are lost due to runoff. The amounts of runoff measured in the northern part of the Negev in Israel range from 30 to 50% in small (6 m^2) plots (Hillel, 1987) to 5-20% in 10 ha plots (Agassi and Arbel, 1981).

Surface runoff is mainly due to crust formation on the soil surface during rainstorms. Crust formation is a result of raindrop impact over the soil surface and aggregate dispersion (McIntyre, 1958).

The permeability of a soil to water and clay dispersion depends also on its exchangeable sodium percentage (ESP) and on the salt concentration of the percolating solution, tending to decrease with increasing ESP and decreasing salt concentration (Agassi et al., 1981).

When leached with rainwater, soil surface will be especially susceptible to crust formation processes because of the low concentration of electrolytes in the rainwater. Formation of crusts (with very low HC) at soil surfaces exposed to rainwater is further enhanced by the impact energy of the raindrops. Increasing the electrolyte concentration in the percolating water above the flocculation value, limits the dispersion process. One way of increasing the electrolyte concentration of the rainwater infiltrating into a soil is by spreading salts over the surface.

Gypsum, because of its general availability and low cost is the most common source of calcium in reclaiming sodic soils and of electrolytes to maintain adequate water infiltration. Phosphogypsum (a by-product of the phosphate fertilisers industry) was found to be much more efficient than mined gypsum in maintaining a high infiltration rate (Keren and Shainberg, 1981). The greater efficiency of phosphogypsum was attributed to the high rate of dissolution of phosphogypsum as compared with the mined gypsum. Lime was found to be ineffective in maintaining the infiltration rate above that of the control.

Agassi et al. (1982) studied the effect of powdered phosphogypsum (PG) on the infiltration rate of five typical soils from the arid and semi-arid regions of Israel in laboratory conditions. In all five soils the IR dropped sharply to 1.5-2.0 mm/h independent of the texture and the ESP of the soils when they were rained with DW.

The effects of different amounts of powdered phosphogypsum on the infiltration rate of a Calcic Luvisol soil from Nahal Oz are presented in Fig.19. Similar curves were obtained for the other soils. Phosphogypsum was very effective in stabilising the structure of the soil surface and in preventing the sharp drop in the infiltration rate. When powdered phosphogypsum was applied, the three quantities of phosphogypsum (3, 5 and 10 ton/ha, respectively) were almost equally effective.

The increase in FIR from about 2 mm/h in the control to about 10 mm/h with the PG treatments is decisive, as almost 80% of the rainstorms in Israel are lower than 8 mm/h of intensity.

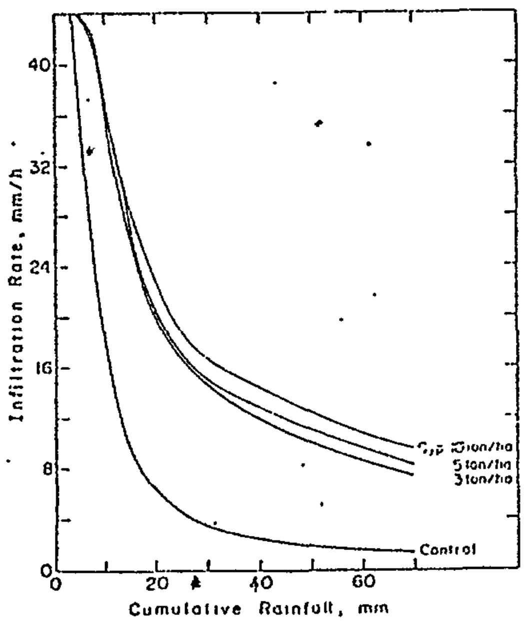


Fig.19 Infiltration rate of Calcic Luvisol soil (Nahal Oz) as a function of cumulative rain. The effect of gypsum quantities.

The phosphogypsum effect on the IR can be explained as follows: the soil crust is the factor that determines the rate of infiltration and its formation is associated with clay dispersion. Clay dispersion at the soil surface (and crust formation) is enhanced both by the impact of the raindrops and the potential of the soil clay to disperse. In these experiments, the rain intensity and the mechanical impact of the raindrops were identical in all the phosphogypsum treatments. Thus, the main effect of the phosphogypsum treatments was on the chemistry of the soil surface. The potential of the soil clay to disperse decreases with an increase in the soil solution concentration (Shainberg et al., 1981). Phosphogypsum dissolution increases the soil solution and decreases the drop in IR. The slight differences in the effects of the different quantities of phosphogypsum on the IR were probably due to two reasons: (a) the irregularity of phosphogypsum over the entire surface in the low-level treatment, (b) the increase in concentration of soluble phosphogypsum in the soil solution due to the kinetics of dissolution, which are affected by the amount of phosphogypsum at the soil surface.

The effect of different methods of PG application on the IR is shown in Fig.20. Phosphogypsum was spread over the soil surface and worked into the soil to a depth of 5 mm. It is evident that mixing the soil with phosphogypsum diminishes its beneficial effect on the IR. As a result of mixing the phosphogypsum with the upper 5 mm of soil, only one-fifth of it is available in the upper 1 mm of the soil, where the crust is formed. Thus, the final IR dropped to only 6 mm/h, compared with a value of 9 mm/h for the treatment where the phosphogypsum was spread over the surface. It was concluded that in soils where crust formation and infiltration rate are problems, incorporating the phosphogypsum with the soil by disk or plough should be discouraged.

The effect of the annual amount of rainfall and the dry intervals between the rainstorms, on the efficiency of PG as amendment is shown in Fig.21. Six consecutive rainstorms of 35 mm each were applied over the soil samples with intervals of 3-5 days between the storms. The maximum cumulative rain in the experiment was 210 mm. This is approximately the amount of precipitation in the region up to the time that the wheat canopy becomes dense enough to protect the soil from the impact of the raindrops and consequent crust formation. The IR curve of the first rain is shown in Figs.19 and 20. The experiment with the control treatment was stopped after the fourth storm because no effect of consecutive rainstorms was found. The IR curve of the second storm in the control treatment (no phosphogypsum) was much lower than that of the first. This phenomenon is well documented in the literature (Morin and Benyamini, 1981) and is explained by the fact that the second storm was applied to an already crusted soil. No difference in the IR curve was obtained between the 4th and the 2nd storms, suggesting that the crust had already developed at the end of the first storm, and no change in the hydraulic properties of the crust took place in the consecutive storm.

The infiltration rate curves for the soil samples treated at the rate of 5 ton/ha of phosphogypsum showed that its effect was very pronounced. The IR at the end of the second storm remained at 10.3 mm/h, compared with 13.5 mm/h at the end of the first storm. The effect of phosphogypsum was still maintained at the end of the sixth storm and the IR dropped to only 7.8 mm/h.

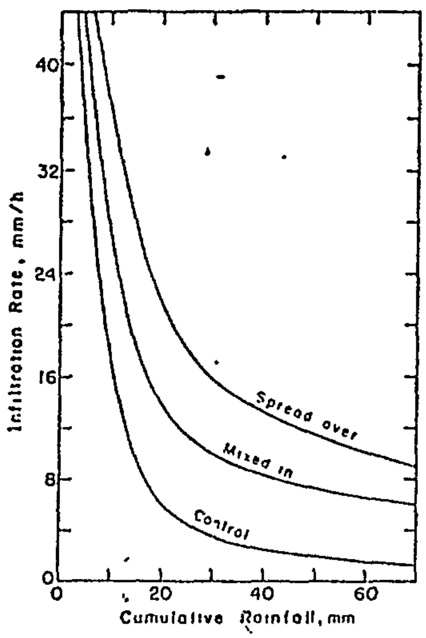


Fig.20 Infiltration rate of Calcic Luvisol soil (Nahal Oz) as a function of cumulative rain. The effects of the method of gypsum application.

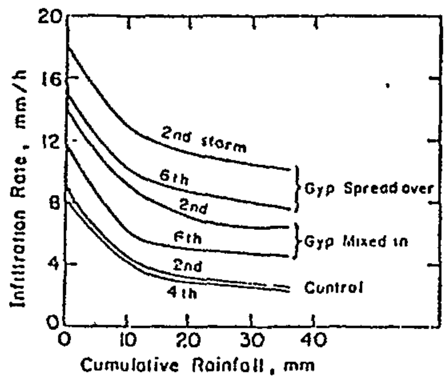


Fig.21 Infiltration rate of Calcic Luvisol soil (Nahal Oz) as a function of cumulative rain. The effects of consecutive rainfalls and gypsum application.

In the mixed-in treatment, the effect of phosphogypsum was intermediate, and there was a sharp drop in the IR curve in the sixth storm. In practice, we can expect that the effect of phosphogypsum will last throughout the winter and that mixing the soil with phosphogypsum will reduce its effectiveness. Phosphogypsum is effective only as long as it is present at the soil surface in amounts sufficient to keep the concentration of the soil solution above the flocculation value.

The seedbag for wheat in the Vertic Luvisol soils contain a relatively high percentage of large aggregates, compared with the average size of the aggregates in the Calcic Luvisol soils. The effects of aggregate size on the efficiency of the phosphogypsum treatment (5 ton/ha, spread over) in the Vertic Luvisol soil (Kedma) are shown in Fig.22. In the control treatment, the IR curve of the 0-10 mm aggregates was higher than that of the 0-3 mm aggregates, whereas the opposite was true in the phosphogypsum treatment where the IR of the 0-3 mm aggregate size was higher than that of the 0-10 mm aggregate size. The effects of aggregate size in the control are easily understood. The large aggregates are more stable and more difficult to disperse, and thus the IR is maintained at higher values. Close observations at the surface of the samples treated with phosphogypsum indicate the reason for the opposite trend in the phosphogypsum treatment. During the rain application, the phosphogypsum powder was washed by erosion from the large aggregates surfaces and was deposited in the intervening depression. As a result of the phosphogypsum erosion from surfaces of large aggregates, clay dispersion and crust formation took place on those surfaces. Thus the IR at the aggregate surfaces diminishes noticeably and the effect of phosphogypsum is evident only in the soil depressions.

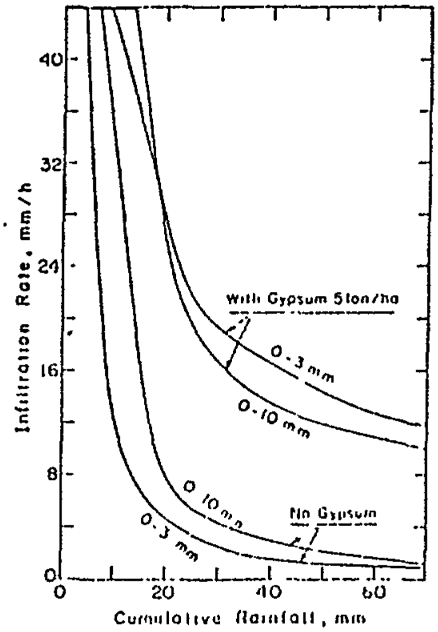


Fig.22 Infiltration rate of Vertic Luvisol (Kedma) as a function of cumulative rain. The interactions between gypsum and aggregate size.

In order to verify these findings, experiments in the field with a portable rainfall simulator were conducted (Agassi et al., 1985). Small field plots of 2 x 2 m were constructed at Alumim (Calcic Luvisol) and Kedma (Vertic Luvisol). The plots of Alumim were subjected to three consecutive simulated rainstorms (distilled water) of 34 mm/h intensity by the portable rainfall simulator (Morin and Yarosh, 1977). Each storm added 50 mm of water, with intervals of 24 hours between storms. Runoff rates and erosion were recorded. Various methods of phosphogypsum application (5 t/ha) were tested: (a) PG was spread over the soil surface and immediately wetted with the rainfall simulator; (b) PG was spread over the soil surface, worked into the soil by drill operation, and simulated rain was applied; (c) PG was spread over the soil surface and was left for three weeks before rain was applied to the plots with the rainfall simulator (wind erosion).

These experiments were designed to study the proper time to spread the PG on wheat fields. Should it be before the seeding when it will be worked into the soil by the drill operation, or after the seeding when it might be exposed to a possible wind erosion?

The effects of consecutive 50 mm rainstorms on the infiltration rate of Alumim loess (ESP 4.3) treated with phosphogypsum are presented in Fig.23. The IR curves for the second storm were in between those presented in Fig.23. The following should be noted. The IR of the control treatment dropped sharply but the final steady-state value was not reached at the end of the first storm (50 mm rain).

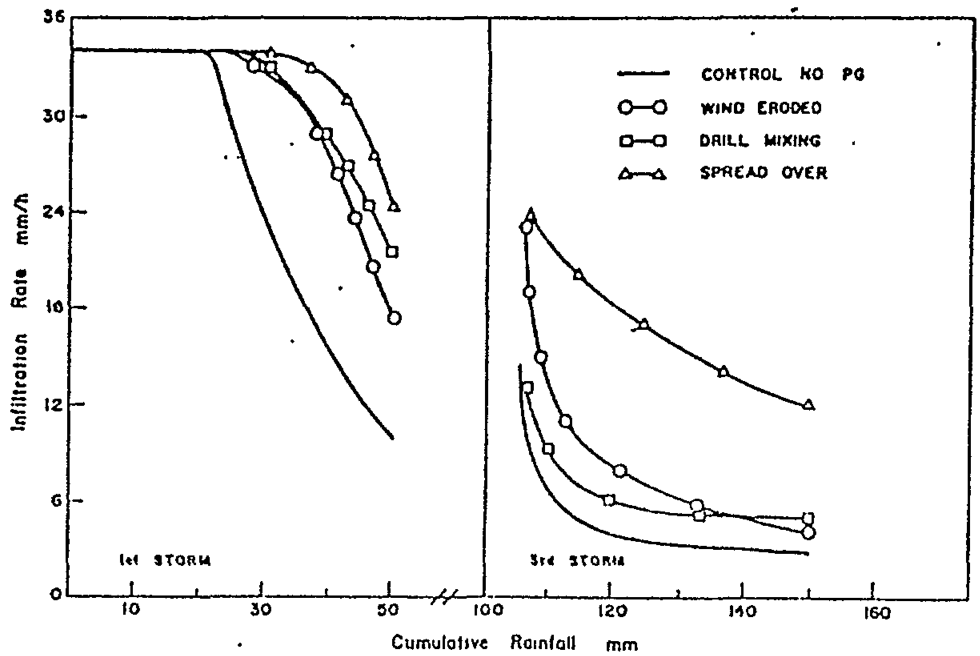


Fig.23 The effect of consecutive storms (1st and 3rd storms) on the infiltration rate of Alumim Calcic Luvisol (ESP 4.3) treated with phosphogypsum (small field-plot experiments).

Subjecting the same soil to a simulated rainstorm with a laboratory rainfall simulator (Fig.24) resulted in a steeper drop in the IR and the FIR was almost reached after 50 mm of rain. In the small-plot experiments, the FIR was reached only during the third storm but the final value was similar to that obtained in the laboratory experiments. Two reasons may account for the differences in the shapes of the IR curves between the laboratory and the small field plots: (a) in the laboratory experiments, the soil in the boxes was saturated from below and thus some soil swelling and aggregate dispersion took place before rain was applied; (b) the aggregate size in the laboratory experiments was 10 and the 8-10 mm size fraction constituted only 25% of the soil sample weight. In the small field plots, however, as a result of the wheat seedbed preparation, aggregates 8 mm constituted 85% of the 0-5 cm soil layer weight. Moldenhauer and Kemper (1969) and Morin and Yarosh (1977) have already demonstrated that the stability of soil aggregates to raindrop impact increased in a linear way according to their size. The prewetting and the aggregate size however, affect only the rate at which the IR drops to its final value. The final IR value in the small field plot is identical to the value obtained in the laboratory. The final IR of a soil is a function of texture, ESP, the impact energy of the applied rain and the electrolyte concentration of the applied water and does not depend on the aggregate size or on the properties of the soil profile (Agassi et al., 1981; Morin and Yarosh, 1977). The crust which forms at the soil surface determines the FIR (Morin and Benyamini, 1981).

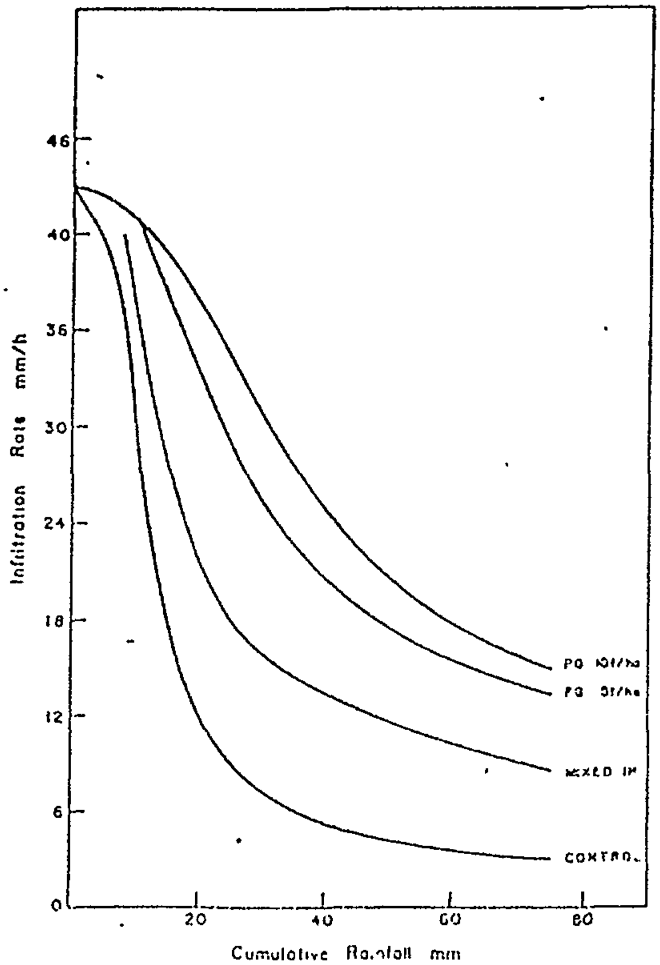


Fig.24 The effect of phosphogypsum application rates and methods of application and the infiltration rate of Alumim Calcic Luvisol (ESP 4.3) (laboratory experiments).

The method of PG application had a pronounced effect on the IR of the Alumim loessial soil. Spreading PG on the soil surface was the most effective treatment, followed by mixing the PG with the soil by the drill operation. Exposing the PG powder to wind erosion for three weeks prior to rain application decreased its effectiveness, whereas the spreading of 5 t/ha of PG followed immediately by rain treatment, maintained the IR at 12 mm/h after 150 mm of rain. The respective IR values of PG mixed with the soil by the drill operation and the treatment by which the PG was exposed to wind erosion treatments were only 4 and 4.8 mm/h. This means that any treatment which reduces the amount of the amendment at the soil surface also reduces its effectiveness. In practice, spreading PG should be the last operation in the wheat fields. This conclusion is further supported by a laboratory study, which showed that 5 mm of rainfall were enough to bind the PG to the soil and to prevent its erosion by wind. The probability of such a light rain in the autumn, following seeding, is high in Israel with its Mediterranean climate.

The effect of phosphogypsum on the IR of the Vertic Luvisol soil (ESP 13) in the laboratory and small field plot experiments is presented in Fig.25. The FIR of the control and 5 t/ha treatment are similar for both the laboratory and the field experiments. The decrease in IR, however, is steeper in the laboratory experiments. Reasons for this phenomenon have already been discussed. In the laboratory experiments, the IR curves for 5 and 10 t/ha of PG treatments were similar (Fig.25). Similar observations had already been reported by Agassi et al. (1982). Conversely, in the field experiments, the treatment with 10 t/ha of PG was more effective in maintaining high IR, and this difference decreased gradually with cumulative rainfall. It seems that phosphogypsum has to be spread uniformly in order to maintain high IR. In the laboratory experiments, the 5 t/ha treatment was enough to achieve a uniform distribution over an area of 1500 cm^2 with an aggregate size of 0-10 mm. In the field plots with much coarser relief, however, this amount was not sufficient to maintain uniformity of spreading. Only when 10 t/ha of PG were applied was uniform distribution of the PG particles over the soil surface maintained.

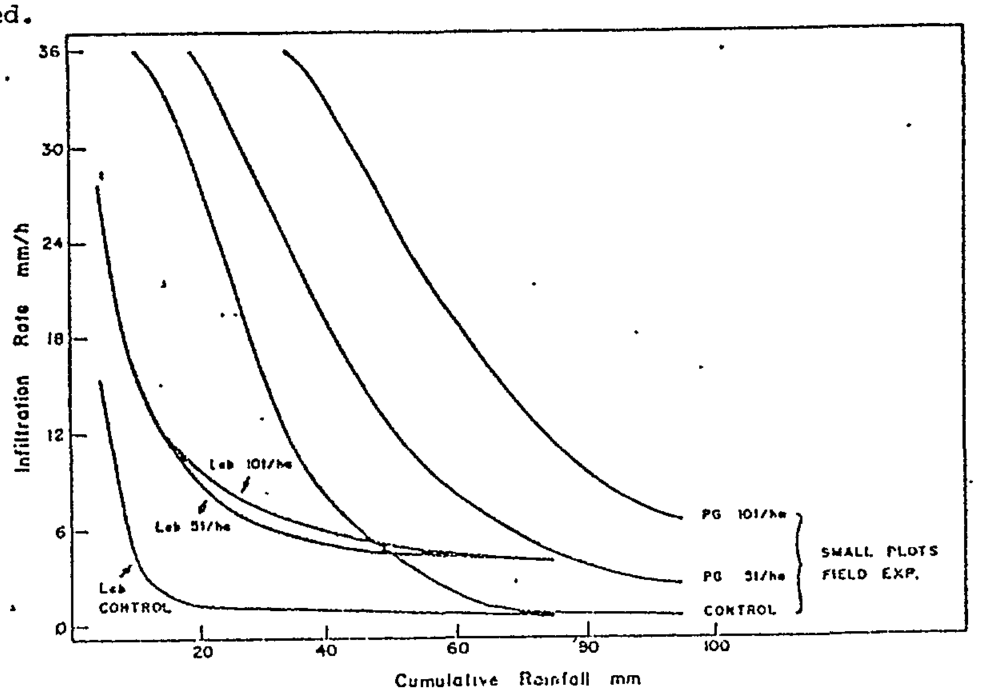


Fig.25 The effects of phosphogypsum application rates on the infiltration rate of Kedma Vertic Luvisol (ESP 13) (laboratory and small field plots experiments).

A practical result of this experiment was that for Vertic Luvisol with ESP 13, ten t/ha of PG was used in the field plots.

7.2 Field studies

The efficiency of PG in controlling runoff and erosion was studied for three years in Wischmeier plots of 125 m^2 (5 x 25 m) on three locations, Alumim and Dvir with Calcic Luvisol and Kedma with a Vertic Luvisol. Phosphogypsum at rates of zero, 5 and 10 t/ha was spread over the soil following the seeding. Each treatment had three replications. After each rainstorm which induced runoff, the amount of runoff was measured. Finally the wheat was harvested and the yield was recorded. In a few experiments, runoff was measured from plots with a wheat seeding but no seeds and no

phosphogypsum were applied (the "exposed" treatment). The difference in runoff between the control and exposed treatment was attributed to the effect of the wheat canopy on crust formation and runoff. In other experiments the effects of slope length (5 and 25 m) on the runoff/rainfall ratio were studied.

Wischmeier plots (natural rain)

The precipitation in the winters of 1980-1981 and 1981-1982 was only 60-70% of the annual average, whereas that in the winter of 1982-83 was higher than the annual average. The yearly amounts of rainfall, runoff, erosion and wheat yields in the runoff plots are given in Table X. The amounts of runoff for each storm during the three winters in Dvir and Alumim are presented in Figs.26 and 27. The results for each site are discussed separately.

Table X

Rainfall, runoff, erosion and wheat yields in the runoff plots

Location and slope (%)	Year	Rainfall (mm)	Treatment[1]	Runoff (mm)	Soil erosion (t/ha)	Yield (t/ha)
Dvir (8.0)	1980/81	229	Control	39.4	1.4	2.55
			PG, 5 t/ha	11.1	0.3	3.14
			PG,10 t/ha	5.7	0.1	3.14
	1981/82	159	Control	7.3	0.13	0.48
			PG, 5 t/ha	0.3	0.10	0.69
			Exposed (no sheat, no PG)	10.9	0.3	
	1982/83	361	Control	0	0	4.08
			PG, 5 t/ha	0	0	4.08
Alumim (2.5)	1980/81	217	Control	23.0	-	0.98
			PG, 5 t/ha	12.2	-	1.22
			PG,10 t/ha	12.5	-	1.28
	1981/82	249	Control	23.4	0.5	0.43
			PG, 5 t/ha	3.6	0.1	0.88
			Exposed	28.0	0.4	-
	1982/83	633	Control 25 m	124.3	1.54	3.10
			PG, 5 t/ha	34.1	0.60	3.10
			Control 5 m	212.0	4.87	-
Kedma ESP 13 (7.0)	1980/81	362	Control	50.6	11.2	1.65
			PG, 10 t/ha	23.2	3.4	2.20
	1982/83	741	Control	62.1	0.96	3.30
			PG, 10 t/ha	42.2	0.32	3.30

[1] Control : wheat and no phosphogypsum
PG, 5 and 10 t/ha : wheat field spread with 5 and 10 t/ha phosphogypsum respectively.
Exposed : wheat seedbed, without sheat and PG.

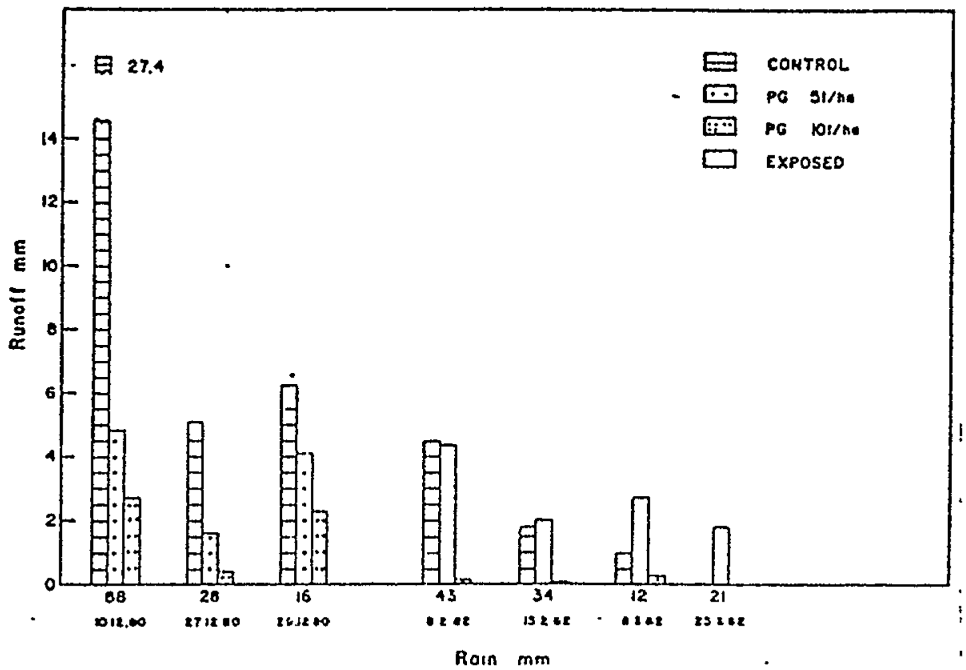


Fig.26 Runoff from each of the rainstorms in Wischmeier plots at Dvir in the winters of 1980-81 and 1981-82.

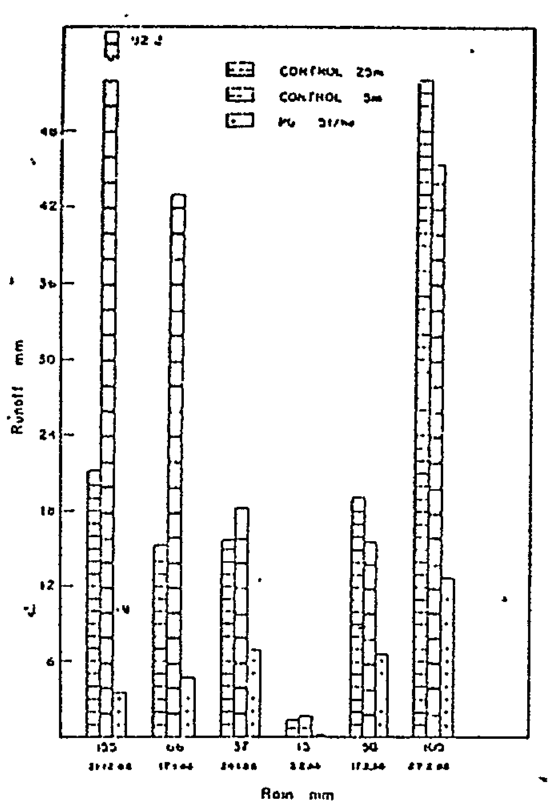


Fig.27

Dvir plots

In the winter of 1980-81, the first rain after seeding occurred in mid December, when 88 mm fell within 44 h. As can be seen from Fig.26, the runoff from this storm was 27.4, 4.8 and 2.7 mm for the control, 5 and 10 t/ha of PG treatments, respectively. Successive rainstorms were much lower in amount and intensity. Compared with the control (Table X), 5 and 10 t/ha of PG reduced the yearly amount of runoff and saved 28 and 33 mm of rain respectively. As a result, the wheat yield increased by 0.59 t/ha. This figure is in agreement with Shalhevet et al. (1976) who found that in this region, in the semi-drought years, the marginal return for each m^3 of water was 2 kg of wheat grain. Although the runoff from the 10 t/ha plots was 5 mm less than that from the 5 t/ha plots, there was no measurable difference in wheat yield between the two treatments. The difference in yield between the control and the phosphogypsum treatments was affected by the uniform distribution of moisture in the PG-treated plots. As a result of the higher IR of the soil treated with PG, the local runoff within the plots was reduced considerably, accumulation of local runoff water in depressions was minimal and this uniform distribution also accounted for the high yield per water ratio. A similar phenomenon was reported by Morin and Rawitz (1983), who measured runoff and yields in sprinkler irrigated cotton fields.

Phosphogypsum was more effective in reducing erosion than in reducing runoff (Table X). Soil erosion was reduced by two mechanisms: (a) reducing runoff; (b) stabilising the structure at the soil surface. A combination of these two mechanisms leads to low erosion rates.

In the winter of 1981-82, treatment with 10 t/ha of PG was replaced by the "exposed" treatment. In this treatment, the wheat seedbed was prepared but no wheat was sown and no PG was spread. This treatment was designed to study the effect of the wheat canopy on runoff and erosion in the field. In the winter of 1981-82 the first effective rain fell only at the beginning of February. In other words, the winter in this region started at the beginning of February instead of the middle of November.

As shown in Fig.26, until the rainstorm of March 8, 1982, there was little difference between the control and the exposed treatment in runoff. The accumulated amount of rainfall until that storm was 127 mm. Until the beginning of March, the wheat canopy in the control plots was not dense enough to prevent raindrop impact, thus crust formation and reduction in IR were similar in the control and exposed fields.

The amount of runoff from the March 8, 1982 rainstorm was higher in the exposed treatment than in the control. In March, air temperatures increased and the wheat canopy developed rapidly. As a result of the drying periods between rainstorms, the crust which was formed during February rainstorms became fissured, and the IR of the soil increased slightly (Morin and Benyamini, 1981). When the following rains came, the wheat canopy in the control treatment protected the fissured crust from the impact of raindrops and the IR of the soil remained higher than the IR of the unprotected "exposed" treatment. In these plots, as a result of raindrop impact, the fissured crust was rebuilt very quickly and the IR was reduced. Thus, the difference in amounts of runoff from these two treatments is due to the canopy development and the retarded crust-rebuilding processes in the control.

In spite of the drought in 1981-82, the PG treatment reduced the runoff from 7.3 mm in the control to 0.3 mm (Table X). As a result of that reduction, the wheat yield increased from 0.48 t/ha in the control plots to 0.69 t/ha in the PG plots. From the point of view of the farmer none of these increases is economically significant.

In the winter of 1982-83, the annual amount of rain was 361 mm. No runoff was observed from the plots during that winter. By analysing the intensity of the rainstorms, we found that the intensities in that winter never exceeded 2 mm/h. In the laboratory studies (Fig.24) with a continuous rainfall intensity of 44 mm/h, the final IR was 3.0 mm/h for the control treatment and 13.4 mm/h for 5 t/ha of PG. Thus, no runoff was expected and no difference in wheat yield was obtained.

Alumim plots

The results at this location were similar to those at the Dvir location. Thus, only the results of the 1982-83 winter when the effect of plot length on amount of runoff was studied, will be discussed in detail.

In the winter of 1982-83, control plots, 5 m long, were introduced in order to study the effect of plot length on the amount of runoff. As seen from Fig.27, there was a considerable difference in the amount of runoff between the 5 and 25 m long plots in the first two rainstorms. Similar observations were reported elsewhere (Lal, 1983). Observations during the rainstorm showed that much more runoff water was stored in the depressions on the soil surface of the longer plots in comparison with the shorter ones. In order to clarify the effects of this phenomenon, ditches were cut in the longer plots to connect the depressions to the outlet for runoff water. As a result, the amounts of runoff from the subsequent rainstorms were similar in the long and short plots. The high efficiency of PG was proved again in that year. Even in the last rainstorm, after 528 mm of rain had fallen, PG reduced runoff by 76% as compared with the control.

As shown in Table X, the amount of runoff from the control plots 25 m long was 124 mm, thus 509 mm of rainwater percolated into the soil. With that amount of precipitation, water was not a limiting factor and the average wheat yield for the control and PG plots was 3.10 t/ha.

Kedma ESP 13 plots

The experiment with the portable rainfall simulator (Fig.25) showed that in this area, 10 t/ha of PG was much more effective than 5 t/ha for runoff control. Thus two treatments were studied at Kedma, the control and 10 t/ha of PG.

In the winter of 1980-81, the first rains fell in the middle of December. As shown in Table X the PG treatment as compared to the control reduced the runoff amount to 46% and reduced the amount of eroded soil material to 30% of the latter. As a result of the reduction in runoff achieved by the PG, this treatment gained 274 m^3.ha of water and the wheat yield increased by 0.55 t/ha. As in Dvir and Alumim plots, the marginal return for each m^3 of water was 2 kg of wheat grain.

In the winter of 1982-83, the wheat was sown on December 3, 1982 and four days later 120mm of rain fell. The amount of runoff from that rainstorm was very low because of roughness of the soil surface created high surface storage.

As a result of the early sowing of the wheat and the relatively early rain, the wheat grew very fast and the plots were covered with a very dense and effective canopy. Thus, the runoff was quite low (compared with Alumim) and the difference between the control and PG treatments was very small. As in the Alumim plots, water was not a limiting factor and the average wheat yield was 3.30 t/ha.

Shoval plots

The effect of 5 t/ha of PG spread over the soil surface was studied also for three years by Morin et al. at Shoval with Calcic Luvisol soil. Plots of 20 by 40 m were conducted in a commercial wheat field with a slope of 3%. The annual precipitation in this area is 300 mm. The precipitation in the three years of the experiment was lower than the annual average and the distribution of the rainfall during the winter was very bad. Thus the wheat yields were very poor.

The effect of the PG on the runoff and wheat yield is presented in Table XI.

Table XI

Year	Rainfall (mm)	Runoff (mm) (control)	Yield (t/ha)	
			Control	P.G.
1983-4	143	traces	0.38	0.53
1984-5	182	16	0.99	1.70
1985-6	216	2	0.44	0.62

In spite of the low precipitation and the relatively low amounts of runoff, PG increased the yield by 1.4-1.7 times than the control. It was assumed that the PG brings more uniform distribution of moisture in the soil, as there is less runoff and less accumulation of runoff water in local depressions.

7.3 Phosphogypsum as amendment for runoff and erosion control in potato fields

Potatoes in Israel grow in ridged furrowed fields (Fig.28) with slopes of 1-7%. In winter time the fields are exposed to the destructive direct impact of the raindrops. As a result, over 30% of the annual rainfall becomes runoff, causing severe erosion in the fields. The farmers need to rebuild the ridges at least twice during the winter.

An experiment was conducted in a commercial potato field in order to study the efficiency of PG on runoff and erosion control. The field was located at Nir-Eliahu in the coastal plane where the annual average precipitation is about 600 mm. The soil is Chromic Luvisol with a slope of 6% and ESP of 2.8. The direction of the furrows was parallel to that of the field slope.

Another method for runoff control studied in this experiment was dyked furrows (basin listing Fig.25; Unger, 1984). The dykes are made of earth by special equipment in intervals in accordance with the field gradient. The effect of this technique was discussed in section 6.

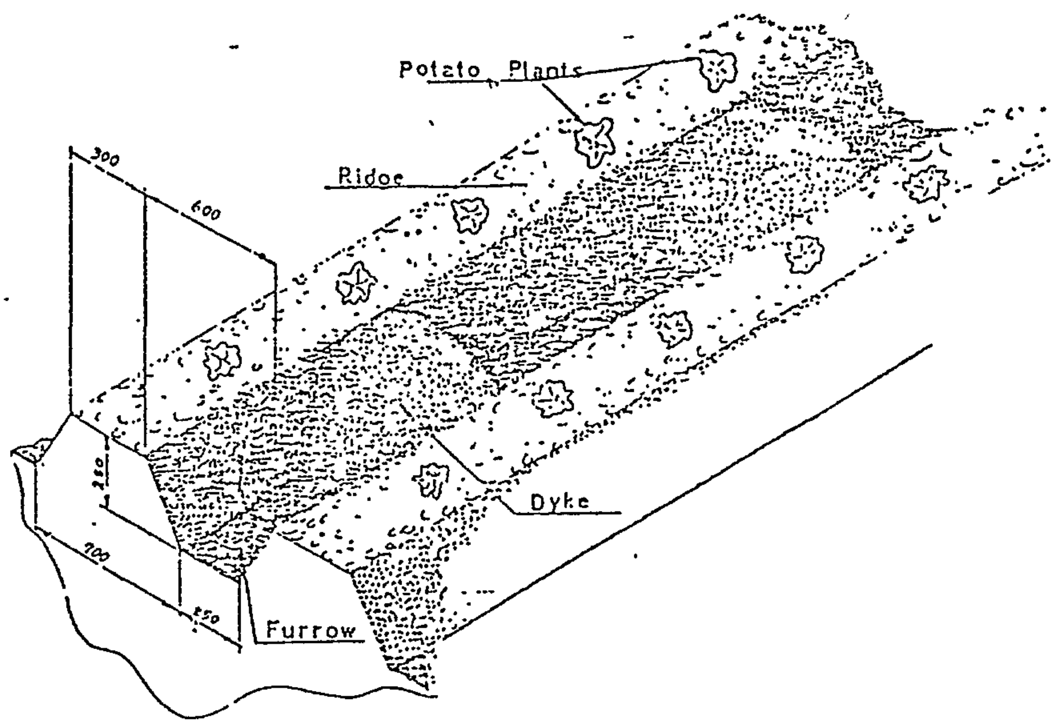


Fig.28 A sketch of ridges, furrows and earth dykes in the furrows

The treatments were: (a) control, (b) dyked furrows built after the seeding, (c) ten tons per hectare of PG spread over the soil surface after seeding. There were three replicates for each treatment. Each plot was 4 x 80 m. The runoff from each plot was recorded as well as the rainfall. The total amount of rainfall in that year of the experiment was only 240 mm. The amount of runoff from each of the rainstorms which induced runoff is given in Table XII. The table shows that the amount of runoff in the control was six times higher than that in the PG treatment. In the dyked furrows treatment there was no runoff at all.

The cross cut section of the ridges was measured after the first rainstorm which compacted the loose soil. The area of the cut was 1,430 cm^2. The same measurements were taken at the end of the winter. It was found that the area of the cross cuts was 800 and 1,400 cm^2 in the control and PG treatments respectively. In the PG treatment, there was no erosion at all compared to the severe erosion in the control even in such a low precipitation year.

Table XII

Date of the rainstorms	Depth of rain in each of the rainstorms (mm)	Control		Phosphogypsum	
		Depth of runoff (mm)	Percent of runoff from rainfall	Depth of runoff (mm)	Percent of runoff from rainfall
11.01.86	27.7	1.8	6.5	0	0
14.01.86	19.1	1.5	7.9	0	0
18.01.86	9.6	1.3	13.5	0.2	2.1
05.02.86	42.0	6.5	15.5	1.7	4.0
09.02.86	25.6	6.8	26.4	1.0	3.9
TOTAL:	126.0	17.9	7.5 *	2.9	1.2 *

* Percent of runoff from total rainfall (240 mm)

The potatoes were harvested and classified into grade A and B according to their size and quality. The results are presented in Table XIII.

Table XIII

Treatment / Criteria	Control	Dyked furrows	Phosphogypsum
Total weight t/ha	50	60	47
Percent of grade A bulbs	87	84	90

There was no significant difference in the yield between the control and PG treatments. In the dyked furrows, the yield increased significantly by 10 t/ha. It is not clear why there was no increase in the yield with the PG treatment. It might be that it is connected to the availability of potassium in the presence of PG in the soil.

This phenomenon will be studied in the winter of 1986-87.

7.4 Reclamation of Vertic Luvisol sodic soil by phosphogypsum

The reclamation of Vertic soil with high sodicity at Kfar Menahem (ESP 23.9) was studied for two years by Keren et al. The experiment was carried out on a commercial field in which the emergence of the cotton seeds was very poor and the yield was accordingly poor. The poor emerging of the seeds is due to the crust which forms over the soil surface by the impact of the raindrops.

The treatments were as follows: (a) control, (b) 10 t/ha of PG spread over the soil surface, (c) 20 t/ha of PG spread over the soil surface, (d) 10 t/ha of PG spread over the soil surface + 10 t/ha which were worked into a depth of 30 cm, (e) 20 t/ha of PG were worked into a depth of 20 cm.

As already noted (Agassi, 1982), spreading PG over the soil surface was the most efficient application for the control of runoff and erosion. In this experiment however, the reclamation of a sodic soil was studied, thus in some of the experiments PG was worked into the soil in order to enhance the substitution of exchangeable sodium with calcium cations.

Each treatment was with three replications (in plots of 6 x 10 m). The slope in the field was 8%. During the rainy season, rainfall and runoff were recorded. In the early spring, the field was seeded with cotton and the number of the seedlings was counted. In the summer the field was irrigated and during harvest time the cotton yield was measured. The effect of 20 t/ha of PG spread over the soil surface on the infiltration rate was studied by the mobile rainfall simulator. The final infiltration rate was 2.0 and 5.8 mm/h in the control and PG treatment respectively.

The effect of PG treatments on different parameters is presented in Table XIV.

Table XIV

Treatment	Runoff mm *** 1982/3	Runoff mm **** 1983/4	Erosion t/ha(82/3)	Average no. of seedlings/m	Cotton yield t/ha. (1984)
Control	115.0	68	17.90	4.5	0.53
10t/ha S.O *	51.0	21	3.75	18.4	1.63
20t/ha S.O	34.5	21	7.82	25.6	1.93
10t/ha S.O ** +10/ha W.I 30cm	54.0	23	4.52	20.4	1.90
20t/ha W.I.	71.0	49	12.36	29.7	1.90

* S.O. = phosphogypsum spread over

** W.I. = phosphogypsum worked in

*** MM of runoff out of 224 mm of rainfall which induced runoff

**** MM of runoff out of 143 mm of rainfall which induced runoff

It is obvious that PG decreased runoff and erosion and improved the seedlings emergence and cotton yield. In that field, spreading 20 t/ha of PG over the soil surface was the most effective treatment. It is hypothesised that 20 t/ha of PG spread over the soil surface covers the surface thoroughly thus the percolating rainwater is saturated with PG and the process of sodium cations substitution is efficient. Incorporating PG into the soil by ploughing, results in a poor uniform distribution of its particles in the soil section and the substitution process is less efficient.

8. CLIMATE AND SOILS IN THE MEDITERRANEAN BASIN WITH RESPECT TO ISRAELI CONDITIONS

In order to show the relevance of the research findings to other Mediterranean countries, the similarities of climate conditions, geology and soils distribution will be presented.

8.1 Climate

The climate of the Mediterranean and its bordering lands presents such marked characteristics that it has been taken as a type climatic region. Its major features are the general absence of rain during the summer half-year and the concentration of rainfall during the cooler six months. This rainfall distribution is accompanied by almost tropical heat in summer and mild winter temperatures. These results arise in part from the position of the sea relative to the general atmospheric circulation and in part from local conditions.

Depressions moving eastward along the polar front, cross the Mediterranean area mainly in winter. Most of them enter the region along a track from the Bay of Biscay to the Gulf of Lions though some pass eastward from the Straits of Gibraltar. They are most frequent between September and February and are the source of the winter rainfall. In summer the Mediterranean lies south of their tracks.

Local depressions develop over both the eastern and western basins throughout the year but have more effect on local wind directions than on rainfall. The position of the sea between the two continental masses gives a continental character to most aspects of the Mediterranean climate. This is most marked in the Levant. The proximity of high mountain ranges produces many local effects. It limits the modifying effect of the sea on temperatures to a narrow coastal strip and emphasises air movements between land and sea. Thus both the Bora of the Adriatic and the Mistral of the Rhone Valley, cold dry winds produced by depressions over the sea, are made more violent by their passage down mountain valleys.

Other characteristic winds are the damp Marin of Southern France, the parching Sirocco from the Sahara and the steady northerly Etesian winds of the Aegean (2). In Israel there is a well developed sea breeze in summer and strong Katabathic easterlies in winter, named locally "Sharkija".

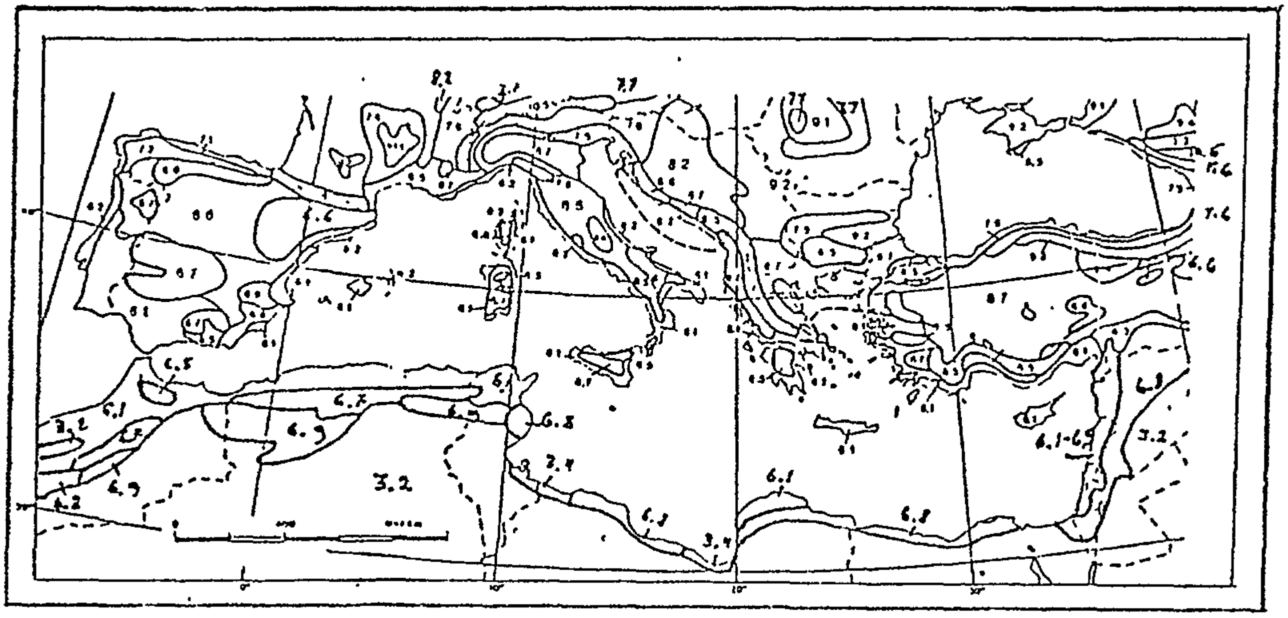
Along the northern margin of the Mediterranean, the February mean temperature is around 7 ^{o}C and along the southern coastline 13 ^{o}C. The respective temperatures for August are 24 ^{o}C and 27 ^{o}C.

To the north, leaving the seashore, the climate becomes colder more rapidly entering the temperate zone. To the south (toward Africa) the temperatures rise slowly entering the global desert belt (3).

The average temperatures in some parts of Israel are as follows (1):

	January	August
Galilee hills	6	22
Tel Aviv	12	26
Gulf of Eilat (Akaba)	14	32

The partition in climatic zones (Koeppen) of the Mediterranean region and the surroundings is given herewith. It is adapted from figures formed in the legends of the "Soil Map of the World" (FAO) (5).



Desert
3.2 Hot subtropical desert
34. Cool subtropical desert
Mediterranean
6.1 Subtropical Mediterranean
6.2 Marine Mediterranean
6.5 Temperature Mediterranean
6.6 Cold Mediterranean
6.7 Continental Mediterranean
6.8 Semi-arid subtropical Mediterranean
6.9 Continental semi-arid Mediterranean
Marine
7.1 Warm marine
7.2 Cool marine
7.6 Cool temperature
7.7 Cold temperature
Continental
8.2 Semi-warm continental
Steppe
9.1 Warm steppe
9.2 Semi-warm steppe
9.3 Cold steppe
9.4 Temperature steppe
Polar
10.5 Alpine

Fig.29 Climate regions

The rainfall in the Mediterranean amounts to 400-800 mm yearly. Higher amounts of precipitation are to be found only under special orographic conditions.

South of the Atlas mountains and from the Gulf of Gaza, there is only a narrow strip of land which receives an appreciable amount of rain. The dry summer, so typical of the Mediterranean, is well expressed only south of the 42nd parallel. Its distribution increases from west to east. In Spain and Italy it lasts only 2-3 months, but in the Levant, 5-6 months are absolutely dry (18).

In Israel the north-south gradient of precipitations is also well developed. In the northern hills, the mean yearly precipitation is close to 1000 mm. In Eilat, the most southern point in Israel, the precipitation is only 35 mm. In the agriculturally most important parts of the country, the rainfall amounts to 300-600 mm. As Israel is part of the Levant, the summer is without any rain.

8.2 Geology

Most of the lands around the Mediterranean Sea are based on sedimentary rocks of various ages, many of them metamorphised, as the whole area was once inundated by the Tethys Sea. Therefore in the rocks, calcium carbonate is the main constituent.

Areas of intrusive igneous rocks are found in western Spain, Corsica, Sardinia, northern Turkey and Thrace. Areas with volcanic rocks occur mainly along the Tyrrhenian coast of Italy, in Sardinia and Turkey and in patches in the Levant (4).

In Israel the rocks of the central mountain massif are limestone, dolomite and chalk of the mesozoic age. On the coastal plain we find sandstone ridges of the Pleistocene age, running parallel to the seashore, vestiges of old coastlines. In the north, in some areas the sedimentary rocks are covered by basaltic flows of Miocenic to Pleistocenic age.

8.3 Soils

The Soil Map of the World (scale 1:5.000.000) edited by FAO-UNESCO (5) was used to describe the distribution of soils in the Mediterranean Sea basin.

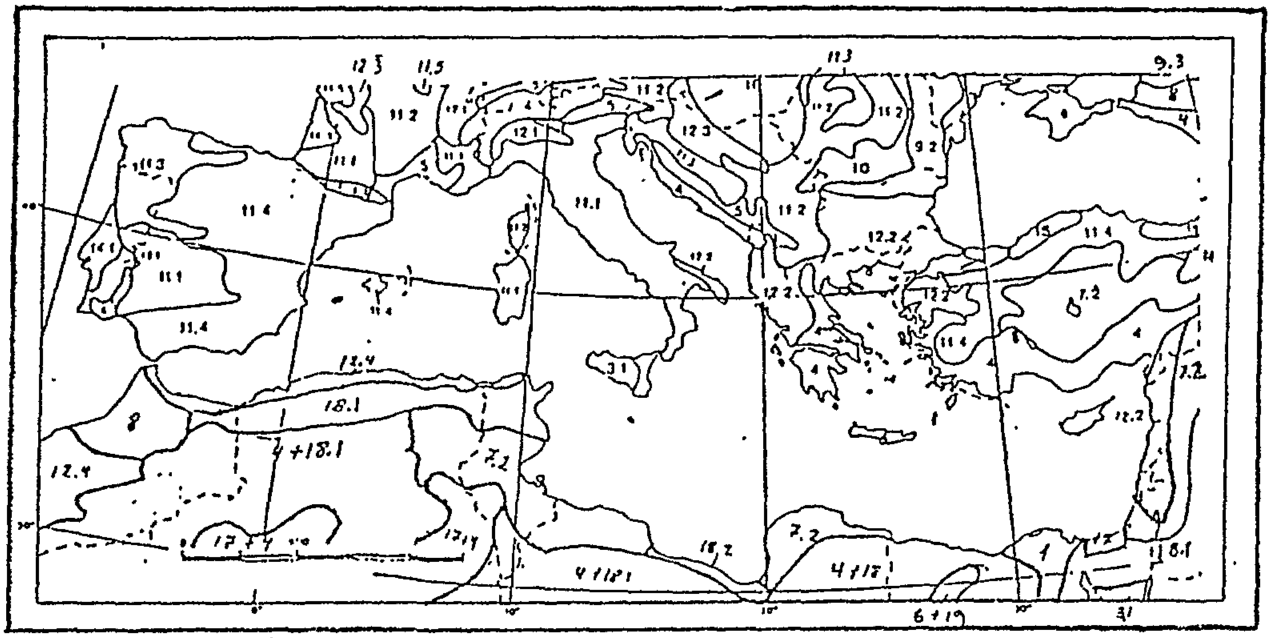
All the common soil groups mentioned above are found in Israel, in accordance with the wide range of annual rainfall (35-1000 mm). Though no Cambisols are shown on the FAO map in the area of Israel, these soils are present quite extensively. (It seems that they are not represented, due to difficulties in the translation of the Israel Soil Classification into the terminology used by the World Map).

From the agricultural point of view the most important soil groups in Israel are:

Vc Chromic Vertisols	(Typic Chromoxererts)	
Lc Chromic Luvisols	(Typic Rhodoxeralfs)	
Lv Vertic Luvisols	(Vertic Haploxeralfs)	U.S. Soil Taxonomy
Lk Calcic Luvisols	(Calcic Haploxeralfs)	

The last may be of quartzic or loessic character.

According to this exposition it seems that the natural conditions in Israel are quite similar to those in other Mediterranean countries, and particularly to those around the southern parts of the sea.



1. Fluvisols
3. Regosols
   - 3.1 Eutric and Calcaric Regosols
4. Lithosols
5. Rendzinas
6. Solonetz
7. Xerosols
   - 7.2 Calcic Xerosols
8. Kastanozems
10. Phaeozems
11. Cambisols
    - 11.1 Eutric Cambisols
    - 11.2 Dystric Cambisols
    - 11.4 Calcic Cambisols
    - 11.5 Chromic Cambisols
12. Luvisols
    - 12.1 Orthic Luvisols
    - 12.2 Chromic Luvisols
    - 12.3 Gleyic Luvisols
    - 12.4 Calcic Luvisols
14. Podzols
    - 14.1 Orthic Podzols
15. Acrisols
17. Dune or shifting sands complex
18. Yermosols
    - 18.1 Calcic Yermosols
    - 18. Gypsic Yermosols
19. Solonchaks

Fig.30 Major soil regions.

8.4 Applicability of research findings to regions in the Mediterranean Sea basin

It seems that the results from the experimental sites may be applicable to the following areas:

- the south-western fringes of the Mediterranean
- the Levant
- the Mediterranean coastal strip of Turkey
- Cyprus and Crete
- Southern Greece
- Southern Italy, Sicily and Sardinia
- Southern Spain

9. RESULTS, CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE COOPERATION

9.1 Results and conclusions

The effects of the inter-relationships between rainfall and soil properties on the infiltration of water into the soil and on the runoff, is under intensive study in Israel. The results and conclusions of these studies may be stated as follows:

(1) It was found that the direct measurement of erosion is an expensive and lengthy process. For Israel and many countries with similar budget and manpower constraints, it was found more practical to study runoff and methods of reducing runoff which in itself automatically reduces erosion.

(2) The study of the relationship between rainfall parameters and soil properties is essential for the better understanding of methods for runoff control.

(3) Rainfall data has to be analysed in order to find which of the rainfall parameters has the best correlation with runoff. There are indications that the kinetic energy of rainfall is one of the most significant factors.

(4) Rainfall simulators are beneficial for infiltration and runoff studies, their prediction and the development of control methods. The advantages of using a rainfall simulator are:

(a) it reduces period of time necessary for obtaining results;

(b) it ensures that the study will be under design rainfall patterns and not left to the haphazardness of natural rainfall;

(c) it gives the possibility of studying the effects of varying rainfall intensities and kinetic energies.

(5) Today we can predict runoff from small basins (2-3 hectares), provided rainfall data is available and that the infiltration rate curves and the surface storage characteristics of the plot are measured by rainfall simulators. The prediction is done for different soil types and methods of runoff control.

(6) The formation of crust over a soil surface, subjected to the direct impact of raindrops, is due to two complementary processes acting simultaneously: (a) disintegration of the soil aggregates into small particles and their rearrangement into a very dense and thin low impermeable layer (1 mm), (b) chemical dispersion of the clay particles, causing their migration into the soil matrix, decreasing the soil pore volume.

(7) In order to prevent the disintegration of the soil aggregates by the direct impact of the raindrops, it is possible to mulch the soil surface with plant residues by scattering small stones. In the case of sprinkler irrigation, it is recommended to use sprinklers which produce a smaller drop size and consequently minimise the kinetic energy.

(8) It is possible to control runoff (and therefore erosion) very efficiently by increasing the soil surface storage. Farm equipment has been developed in order to increase the soil surface storage. This equipment for establishing basins and pitting is adapted for winter cereals and rowcrops. As a result of this type of cultivation, runoff was decreased by 60-70% as compared with the control plots.

(9) In order to prevent the chemical dispersion of the clay particles, it is suggested that soluble electrolyte salts be spread over the soil surface. When rainwater reaches the soil surface, the dissolved salts will increase the salinity of the rainwater, as well as the infiltration rate. Phosphogypsum, a by-product of the phosphate industry has been introduced for this purpose. It was found that by spreading 5 tons per hectare of phosphogypsum over the soil surface, runoff was decreased by 75% as compared with the control treatment.

(10) Water with electrolyte concentration as low as 5 meq/L, is enough to increase considerably the infiltration rate of soils with ESP level over 2%, as compared with distilled water (rainwater).

(11) Low levels of ESP (1-2%) are sufficient to reduce considerably the infiltration rate of the soil. The arable soils in arid and semi-arid regions usually have ESP levels higher than 2%, thus measures (phosphogypsum) are necessary to maintain the infiltration rate in these soils.

(12) Phosphogypsum spread over the soil surface in appropriate quantities, was very efficient in the reclamation of high sodic soils (ESP = 24).

(13) Runoff control measures increased the available rainwater and irrigation water in the root zone, and thus the yield of wheat, cotton and potatoes was considerably increased.

9.2 Recommendations for further co-operation

An open forum for research workers from all interested countries should be conducted as well as the creation of a working committee for co-ordinating activities. The committee will deal with:

(a) principles for defining the areas in the Mediterranean basin where runoff and erosion problems are severe. It will organise the collection of any relevant available data on this area and will develop joint research proposal aimed at defining the reasons for the susceptibility of these soils to runoff and erosion;

(b) the methodology by which runoff and erosion data will be collected and analysed in field plots. Field plots will be selected all over the Mediterranean countries;

(c) establishing 2-3 erosion research centres where rainfall, infiltration and runoff relationships will be studied, using rainfall simulators. Soils from the Mediterranean countries will be sent to these centres in order to study their infiltration rates under different rain energies, slopes, FSP levels, etc;

(d) standardising the methodology by which rainfall data will be collected and analysed. The rainfall data from all of the countries will be sent to the selected centres where it will be analysed;

(e) the definition of a uniform soil classification method;

(f) the construction of a centre for the in situ instruction of soil conservation experts from different countries in rain analysis methods, rainfall, runoff, erosion inter-relationships, operation of rainfall simulators, planning of laboratory and field experiments and the development of soil conservation methods. The centre will also provide instructors for each country;

(g) all the information will be collected and co-ordinated in a central agency so it can be freely exchangeable;

(f) holding inter-regional consultations on applying field practices to increase infiltration and reduce runoff.

This is a general programme for further co-operation among the interested countries. A more detailed programme should be worked out after an initial symposium.

10. BIBLIOGRAPHY

1. 1956. Atlas of Israel. Dept. of Surveys and Bialik Institute.

2. 1958. Enc.Brit. Term: Mediterranean Sea.

3. 1962. Weather in the Mediterranean. Her Majesty's Stationery Office, London.

4. 1972. International Geological Map of Europe and the Mediterranean Region. UNESCO, Paris.

5. 1974. Soil Map of the World. FAO-UNESCO, Paris.

6. 1978. Agricultural handbook Number 537. Predicting rainfall erosion losses. U.S.D.A. stock number 001-000-03903-2.

7. Agassi, M. and Arbel, S. (1981). Soil conservation activity survey in Israel. Prelim. Rep. No.10 and Progress Rep. No. 1,2,3,4 and 5. Isr.Min.Agric., Soil Conserv. Drainage Div., Tel Aviv, (in Hebrew).

8. Agassi, M., Morin, J. and Shainberg, I. (1982). Infiltration and runoff control in the semi-arid region of Israel. Geoderma, 28:345-356.

9. Agassi, M., Morin, J. and Shainberg, I. (1985). Effect of raindrop impact and water salinity on the infiltration rate of sodic soils. Soil Sci.Soc.Am.J., 49:189-190.

10. Agassi, M., Shainberg, I. and Morin, J. (1981). Effect of electrolites concentration and soil sodicity on infiltration rate and crust formation. Soil Sci.Soc.Am.J., 45:848-851.

11. Agassi, M., Shainberg, I. and Morin, J. (1985). Infiltration and runoff in wheat fields in the semi-arid region of Israel. Geoderma, 36:263-276.

12. Agassi, M., Shainberg, I. and Morin, J. (1987). Effect of changes in drop energy and water salinity during a continuous simulated rainstorm on crust reversibility. (sent for publication).

13. Ahuja, L.R. (1973). A numerical and similarity analysis of infiltration into crusted soils. Water Resour.Res., 9(4):987-994.

14. Allmaras, R.R., Burwell, R.E., Larson, W.E. and Holt, R.F. (1966). Total porosity and random roughness of the interrow zone as influenced by tillage. U.S. Dept. of Agric.Conserv.Res. Rep. No.7. U.S. Gov't. Printing Office Washington, D.C.

15. Armbrust, D.V., Dickerson, J.D., Skidmore, E.L. and Ross, O.G. (1982). Dry soil aggregation as influenced by crop and tillage. Soil Sci.Soc. Am.J., 46:390-393.

16. Baver, L.D., Gardner, W.H. and Gardner, W.R. (1972). Soil Physics. 4th ed. John Wiley & Sons, New York.

17. Benyamini, Y. (1981). The behaviour of bare soils under rainfall application. Ph.D. Thesis, the Hebrew University, Jerusalem, Israel (Hebrew).

18. Biel, E.R. (1944). Climatology of the Mediterranean Area. Univ. of Chicago Press.

19. Blackmore, A.V., and Miller, R.D. (1961). Tactoid size and osmotic swelling in Ca montmorillonite. Soil Sci.Soc.Am.Proc., 25:169-173.

20. Bolt, G.H. (1979). Soil Chemistry B. Physical chemical models. Elsevier Scientific Publ. Comp., Amsterdam, 479 pp.

21. Bresler, E., McNeal, B.L. and Carter, D.L. (1982). Saline and sodic soils. Springer-Verlag, New York.

22. Burst, H.L. and Woodburn, R. (1942). The effect of mulching and methods of cultivation on runoff and erosion from Muskingum silt loam. Agric.Eng., 28:19.

23. Cass, A. and Sumner, M.E. (1982 a,b). Soil pore structural stability and irrigation water quality. Empirical sodium stability model. Soil Sci.Soc.Am.J., 46:503-506, 507-512.

24. Chen, Y., Trachitzky, J., Brouwer, J., Morin, J. and Banin, A. (1980). Scanning electron microscope observation on soil crusts and their formation. Soil Science, 130:49-55.

25. Chow, V.T. (1954). The log-probability law and its engineering applications. Am.Soc.Civil Eng., (Separate No.536), 80, November.

26. DeBoodt, M., Lennheer, L. de, and Kirkham, D. (1961). Soil aggregate stability indexes and crop yields. Soil Sci., 91:138-146.

27. Dexter, A., Radk, J.K. and Hewitt, J.S. (1983). Structure of a tilled soil as influenced by tillage, wheat cropping and rainfall. Soil Sci.Soc.Am.J., 47:570-575.

28. Duley, F.L. (1939). Surface factors affecting the rate of intake of water by soils. Soil Sci.Soc.Am.Proc., 9:60-64.

29. Edwards, W.R. and Larson, W.E. (1969). Infiltration of water into soils as influenced by surface seal development. Transaction of ASAE, 12(4):463-465; 470.

30. Eigel, J.D. and Moor, I.D. (1983). Effect of rainfall energy on infiltration into bare soil. Proc. National Con. on Advances in infiltration. Dec. 1983, Chicago, IL. pp. 188-200.

31. Evans, D.D. and Boul, S.W. (1968). Micromorphological study of soil crusts. Soil.Sci.Soc.Am.Proc., 32:19-22.

32. Falayi, O., and Bouma, J. (1975). Relationships between hydraulic conductance of surface crust and soil management in typic haplydalf. Soil Sci.Soc.Am.Proc., 33:957-963.

33. Felhendler, R., Shainberg, I. and Frenkel, H. (1974). Dispersion and hydraulic conductivity of soil mixed solution. Trans. 10th Int. Congr. Soil Sci. (Moscow) 1:103-112, Nauka Pub. House, Moscow.

34. Frenkel, H., Goertzen, J.O. and Rhoades, J.D. (1978). Effect of clay type and content, exchangeable sodium percentage, and electrolyte concentration on clay dispersion and soil hydraulic conductivity. Soil Sci.Soc.Am.J., 42:32-39.

35. Frenkel, H., Hadas, A. and Jury, W.A. (1978). The effect of salt precipitation and high sodium concentration on soil hydraulic conductivity and water retention. Water Resour.Res., 14(2):217-222.

36. Gal, M., Arcan, L., Shainberg, I. and Keren, R. (1984). The effect of exchangeable Na and phosphogypsum on structure of soil crust - SEM observations. Soil Sci.Soc.Am.J., 48:872-878.

37. Gumbel, E.J. (1958). Statistics of extremes. Colombia University Press.

38. Gumbs, F.A. and Warkentin, B.P. (1976). Bulk density, saturation water content and rate of wetting of soil aggregates. Soil Sci.Soc.Am.J., 40:28-33.

39. Hadas, A., Wolf, D. and Meirson, I. (1978). Tillage implements - soil structure relationships and their effect on crop stands. Soil Sci.Soc.Am.Proc., 42:632-637.

40. Hillel, D. (1967). Runoff inducement in arid lands. Final technical report submitted to the U.S.D.A. Project No.110 - SWc. 36.

41. Hillel, D.I. and Gardner, W.R. (1969). Steady infiltration into crust-topped profiles. Soil Sci., 108(2):137-142.

42. Horton, R.E. (1940). An approach toward a physical interpretation of infiltration capacity. Soil Sci.Soc.Am.Proc., 5:399-417.

43. Hudson, N.W. (1957). Erosion control and research. Rhodesia Agr.J., 54:297.

44. Keren, R. and Shainberg, I. (1981). Effect of dissolution rate on the efficiency of industrial and mined gypsum in improving infiltration of a sodic soil. Soil Sci.Soc.Am.J., 45:103-107.

45. Kite, G.W. (1977). Frequency and risk analysis in hydrology. Water resources publications - ISBN-0-918334-23-3.

46. Lal, R. (1983). Effect of slope length on runoff from Alfisols in western Nigeria. Geoderma, 31:185-193.

47. Linden, D.R. (1979). A model to predict soil water storage as affected by tillage practices. Ph.D. Thesis, Univ. of Minnesota, St. Paul, MN.

48. Lloyd, E.H. (1970). Return periods in the presence of persistence. Journal of Hyd., 10:291-298.

49. Mannering, J.V. (1967). The relationship of some physical and chemical properties of soils to surface sealing. Ph.D. Thesis Purdue Univ., Lafayette, IN.

50. McIntyre, D.S. (1958). Permeability measurements of soil crusts formed by raindrop impact. Soil Sci., 58:185-189.

51. McNeal, B.L. (1968). Prediction of the effect of mixed salt solutions on soil hydraulic conductivity. Soil Sci.Soc.Am. Proc. 32:190-193.

52. McNeal, B.L. and Coleman, N.T.Y. (1966). Effect of solution composition on soil hydraulic conductivity. Soil Sci.Soc.Am.Proc., 30:308-312.

53. Moldenhour, W.C. (1970). Influence of rainfall energy on soil loss and infiltration rates: 2. Effect of clod size distribution. Soil Sci.Soc.Am. Proc., 34:673-677.

54. Moldenhour, W.C. and Kemper, W.D. (1969). Interdependence of water drop energy and clod size on infiltration and clod stability. Soil Sci.Soc.Am. Proc., 33:297-301.

55. Moor, I.D. (1981). Infiltration modified for surface effect. Journal of the Irrigation and Drainage Division. ASCE, 107(IRI):71-79.

56. Moor, I.D. and Larsen, C.L. (1980). An infiltration run-off model for cultivated soils. Transactions of the ASAE, 23(6):1460-1467.

57. Morin, J. and Benyamini, Y. (1977). Rainfall infiltration into bare soils. Water Resour.Res., 13:813-817.

58. Morin, J., Benyamini, Y. and Michaeli, A. (1981). The effect of drop impact on the dynamics of soil surface crusting and water movement in the profile. J. of Hydrology, 52:321-335.

59. Morin, J. and Cluff, C.B. (1980). Runoff calculation on semi- and watersheds using infiltration equations determined from rotodisk rainulator. Water Res., 16:1080-1093.

60. Morin, J., Goldberg, D. and Seginer, I. (1967). A rainfall simulator with a rotating disk. Trans.Am.Soc.Agric.Eng., 10:74.

61. Morin, J., Keren, R., Benyamini, Y. and Shainberg, I. (1987). Infiltration as affected by the soil crust and the water moisture profile. In press.

62. Morin, J., Rawitz, E. and Ariel, D. (1985). Conservation tillage management for wheat production in arid zones. The Israel filed crop association. Final report presented to the German-Israel Fund for Research and International Development. pp.27.

63. Morin, J., Rawitz, E., Benyamini, Y., Hoogmoed, W.B. and Etkin, H. (1984a). Tillage practices for soil and water conservation in the semi-arid zone. 2. Development of the basin-tillage system in wheat fields. Soil and Tillage Research, 4:155-164.

64. Morin, J., Rawitz, E., Hoogmoed, W.B. and Benyamini, Y. (1984b). Tillage practices for soil and water conservation in the semi-arid zone. 3. Runoff modelling as a tool for conservation tillage design. Soil and Tillage Research, 4:215-224.

65. Morin, J. and Yarosh, H.S. (1977). Runoff rainfall analysis for bare soils. Pamphlet Agric.Res.Org., Bet-Dagan, 164.

66. Oster, J.D. and Schroer, F.W. (1979). Infiltration as influenced by irrigation water quality. Soil Sci.Soc.Am.J., 43:444-447.

67. Quirk, J.P. and Schofield, R.K. (1955). The effect of electrolyte concentration on soil permeability. J.Soi.Sci., 6:163-178.

68. Rawitz, E. and Hazan, A. (1978). The effect of stabilized hydrophobic aggregate layer properties on soil water regime and seedling emergence. Soil Sci.Soc.Am.J., 42:787-793.

69. Rawitz, E., Morin, J., Hoogmoed, W.B., Margolin, M. and Etkin, H. (1983). Tillage practices for soil and water conservation in the semi-arid zone. 1. Management of fallow during the rainy season preceding cotton. Soil and Tillage Research, 3:211-231.

70. Rhoades, J.D. and Ingvalson, R.D. (1969). Macroscopic swelling and hydraulic conductivity properties of four vermiculitic soils. Soil Sci.Soc.Am. Proc. 33:364-369.

71. Seginer, I. and Morin, J. (1970). A model of surface crusting and infiltration of bare soils. Water Resour.Res., 6:629-634.

72. Shainberg, I. and Oster, J.D. (1978). Quality of irrigation water. IIIC Publication No.2. Volcani Center, P.O. Box 6, Bet Dagan, Israel.

73. Shainberg, I., Rhoades, J.D. and Prather, R.J. (1981). Effect of low electrolyte concentration on clay dispersion and hydraulic conductivity of a sodic soil. Soil Sci.Soc.Am.J., 45:273-277.

74. Shainberg, I., Rhoades, J.D., Suarez, D.I. and Prather, R.J. (1981b). Effect of mineral weathering on clay dispersion and hydraulic conductivity of sodic soils. Soil Sci.Soc.Am.J., 45:287-291.

75. Shalhevet, J., Mantell, A., Bielorai, H. and Shimshi, D. (1976). Irrigation on field and orchard crops under semi-arid conditions. Publ.Int.Irrig.Inf.Center, 1:7-15.

76. Tackett, J.L. and Pearson, R.W. (1965). Some characteristics of soil crusts formed by simulated rainfall. Soil Sci., 99(6):407-413.

77. Unger, P.W. (1984). Tillage effect on surface soil physical conditions and Sorghum emergence. Soil Sci.Soc.Am.J., 48:1423-1432.

78. Unger, P.W. (1984). Tillage systems for soil and water conservation. FAO Soil Bulletin, 54:496.

79. Van Olphen, H. (1977). An introduction to clay colloid chemistry, 2nd ed. John Wiley & Sons, New York.

80. Warkentin, B.P., Bolt, G.H. and Miller, D. (1957). Swelling pressure of montmorilonite. Soil Sci.Soc.Am.Proc., 21:495-497.

81. Wischmeier, W.H. (1959). A rainfall erosion index for a Universal Soil Loss Equation. Soil Sci.Soc.Proc., 23:246-249.

82. Wustamidim and Douglas, L.A. (1985). Aggregate breakdown in relation to raindrop energy. Soil Sci., 139:239-242.

83. Yaron, B. and Thomas, G.W. (1968). Soil hydraulic conductivity as affected by sodic water. Water Resour.Res., 4:545-552.

INTEGRATED APPROACH FOR THE MANAGEMENT OF WATERSHEDS IN ITALY CATCHMENT OF THE STAGGIA STREAM

by

F. MANCINI and S. GRAZI
Faculty of Agriculture and Forestry
University of Florence, Italy

1. GENERAL INFORMATION ON THE PROBLEM

1.1 Water erosion types and extension in Italy

The national report, submitted in March 1985, deals with the erosion phenomena in some detail (pages 7 to 10). Here, summarising briefly, we recall that water erosion is dominant with all its three types (sheet, rill and gulley erosion). The predominance of sloping terrains is very high in the Mediterranean regions of Italy, with not only the long Appennine chain but also other coastal mountains. It will be sufficient to remember the first and the last one, the Apouanes Alps, and the active volcano, Etna (m 3263 m/S/l). Water erosion phenomena certainly occurs, therefore, in more than four-fifths of the Italian Mediterranean area.

1.2 Causes and consequences of the erosion phenomenon

The principal causes of water erosion in the Mediterranean region of Italy are rain erosivity, soil erodibility, the morphology of the landscape, and human activities.

Rain erosivity may be very high due to the intensity of the precipitations but also because of its duration (sometimes 3-5 days). It is not unknown in Calabria, for instance, that half the annual rainfall occurs over a two-day period. This of course provokes a severe runoff and strong erosion downstream.

Many cultivated soils are poor in organic matter, have a weak structure and an unfavourable texture. It is a matter of fact that a very high percentage of silt, fine, and very fine sand is present in many Mediterranean soils.

As already mentioned, most of the landscapes are undulated or rolling. Many are severely dissected. Slopes are frequently steep and long or very long. This causes, where an efficient systematisation is not present, a dangerous rill formation. Various forms of "bad lands" can be seen in several pre-appenninic hills and in various geolithological formations like argille scagliose, scisti varicolori, and the pliopleistocenic marine grey-bluish silty clays, etc.

Man's influence since prehistoric times has been considerable, not only with regard to agriculture but also with overgrazing, for the appenninic civilisation was in fact a pastoral one. Etruscans and later the Romans used wood for mining and domestic purposes. Thus changes occurred in soil uses, increasing the erosion in many regions.

The consequences of such phenomena are well known. In most catchments slides were and are numerous and in some cases also very large. According to the geolithological formations prevailing in the area falls, slides or flows are most frequent but also mixed mass movements often occur.

The intense runoff and the torrential character of most of the streams provoke floods, inundations with abundant sedimentation also of coarse materials and other damages downstream in the dykes and in the adjacent plains. Where river beds are suspended on the surrounding levees water stagnation may last for a long time, which increases the damages in cultivated fields, in the villages and in urban and industrial areas.

1.3 Outline of the Italian action against erosion

There is an old tradition in Italy of projects and actions concerning water control, soil conservation and in particular battles against water erosion. In the past the plains were unsafe for several reasons (floods, diseases like malaria, large swamps, etc.) or difficult to defend, and so most people lived in the hills or in the mountains in the coastal zones. So it was almost obligatory to preserve the sloping soils against erosion. Terraces with high walls were also constructed in all those landscapes where there are rock outcrops (Liguria, Toscana, Campania, Sicilia). In the sandy or clayey soils other systems were adopted, with fields separated from one another by grass-covered artificial escarpments called "ciglioni".

Running waters were eliminated in various ways; by bringing them into natural drainage channels or preparing paved ditches along the maximum slope along with some steps.

In more recent times works such as these were accomplished by a single farmer but then cooperative efforts were made. Very good laws, for example, called the "bonifica integrale" due to Professor Arrigo Serpieri, and forest laws allowed an integrated approach. The State, farmers' unions, catchments' rehabilitation organisms ("consorzi di bonifica") worked together both in the plains and in the hills in a united approach.

Today most of the activities in agriculture, forestry and soil conservation are carried out by the regional administrations. The State has still the authority in the main inter-regional catchments of the more important rivers (Po, Adige, Tevere, etc.).

1.4 Integrated approach to the management of the watersheds in Italy

The old tradition of studies, projects and actions brought the conviction, especially in the scientific community, that the best results in the rehabilitation of the mountainous catchments can be obtained only with an interdisciplinary research and work with an integrated approach.

This means that already, in past decades when one watershed more or less was of little concern, or was classified as "dangerous" or at "high risk" because there had been frequent and disastrous slides, erosion and floods projects were begun with the participation of several public agencies and especially with interdisciplinary staff. The working party was composed of engineers, geologists, soil scientists, foresters, agronomists and economists in order to have a complete and clear picture of the problems. The catchment was often divided in two parts; downstream there was the Ministry of Public

Works with its local staff (the "Genio Civile") while upstream the Forest Administration pertaining to the Ministry of Agriculture and Forestry had the decision-making power. Today, as already mentioned, it is the Regional Authority that has the right to operate in these areas. The coordination could be closer, though it is not always, the efficiency of the interventions could be improved. It is early days yet and so a definitive judgement cannot be made but while in some regions everything runs well, in others delays and mistakes have occurred.

2. OUTLINE OF THE REGIONAL CONDITIONS WHERE THE PROJECT WAS CARRIED OUT

The selected project is concerned with the catchment of the Staggia stream, the first tributary from the left of the Arno river in Tuscany (Fig. 1). This mountainous area, in the Northern section of the Appennine chain, is dominated by sandstone formations, the so-called famous "macigno", a quartz feldspar micaceous sandstone of tertiary age. Three main types of these graded sandstone formations have been distinguished, macigno A, B and C. The names in common usage are respectively, "macigno del Chianti", "macigno del Mugello" and "marnoso-arenacea". There is a remarkable increase in silty and marly interlayers from the first formation to the last which dominates the eastern slope of the appenninic chain.

Though it is clear that uplift of the chain was strong during the late tertiary and the first quaternary, actual neotectonic phenomena cannot be excluded. These formations were covered, and remnants of various size can be still observed, by an allochtonous complex of clayey nature including rock fragments of quite a different nature (from gabbros and serpentinites to various limestones, jaspers and radiolarites. This complex has several names in the geological literature ("argille scagliose", indifferentiated caothic, the allocthonous). While the sandstones are generally rather stable except in some localities where due to abundant fractures, falls and other slides occur, the "argille scagliose" are well known for their instability. Frequent mass movements of various kinds and dimensions are a distinguishing feature of these landscapes.

Concerning the geomorphology and its dynamics it can be said that strong differences can be seen between the two main above-mentioned geolithological formations. On one side the sandstones give rise to rather abrupt relief with steep slopes, in general covered by natural vegetation or new plantations, predominantly coniferous. The hydrographic network is formed by many rivulets descending subparallel to the main valley. Acclivity is high both in the rivulets' beds and in the floor of the principal stream and becomes weaker further downstream. Coarse materials start being deposited from the first kilometres of the course of the stream which is still flowing in a very narrow valley. At the confluences the valleys appear wider and sediments, often terraced, can be observed. Then in a few miles a narrow strip of alluvial materials, on one, or other or both sides of the torrent is the rule. Further downstream several fluviatile terraces occur, some old and highly suspended on the actual bed and supporting soils of a rather differentiated profile and with a long evolution.

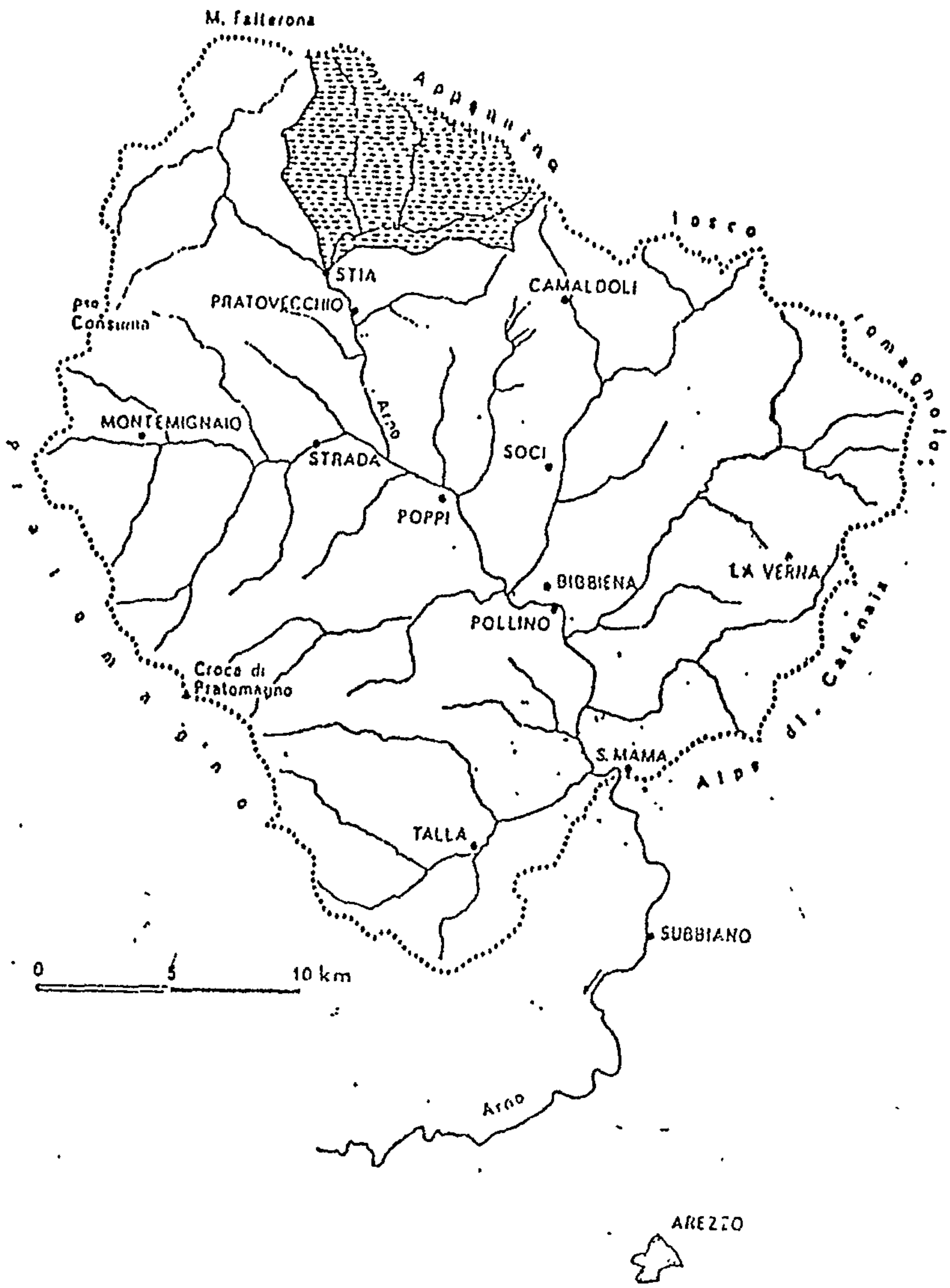


Fig.1 The upper watershed of the Arno River
The watershed of the Staggia Stream

The situation in the area of "argille scagliose" is quite different. The landscape is in general undulated or rolling. Only in the sliding areas the acclivity may be higher or where lithic exotic emerge from the clayey allocthonous mass. These lithic elements, different in size and nature, have no roots. In other words they are embedded in the clays and outcrop today for the prolonged action of a selective erosion. In fact all these bodies of rocks included in the mass are much more resistant than the clays and so over the millennia they have come to the surface and are today higher in comparison with the surrounding more erodible materials.

Some of the landscapes of the argille scagliose are not much disturbed by slides and erosion but in many other areas everything moves and moved in the past. The most striking characteristic is the chaotic aspect of these areas, where the beds of the torrents are filled with coarse and heterogeneous materials while the transport in suspension is also very high because of the erodibility of the clayey soils. The vegetative cover is represented by scanty, poor wood or broad-leaved trees. Land use was mainly pasture at high altitude and cereals and forage crops at a lower level. Many of these farms are actually abandoned of land use is much more extensive than before.

Finally in the lower parts of the valleys both old and recent almost flat alluvial deposits are common and were used for agriculture and settlements. The ancient villages and roads are generally located not near the stream in the new alluvial plain but on the first terrace, well protected from sudden floods and mud flows.

3. OUTLINE OF THE WATERSHED CONDITIONS OF THE CASE STUDY

3.1 Geology and relief

The catchment of the Staggia consists mainly of oligocenic sandstones, as already described. The "Macigno del Mugello" is generally dominant, and is characterised by alternate layers of sandstone and siltstone. Weathering therefore is not slow. The other type of the "macigno", that of Chianti, where sandstone is prevalent, is present (Fig. 2). Some marly limestones and clayey schists appear in the medium part of the valley while in the lower section a narrow band of coarse alluvial sediments is also present.

The relief that originated in these formations is in general strong. Acclivity is in most localities high. The landscape is dissected with narrow secondary valleys. The lower course shows a wider valley and milder slopes. The valleys are separated from each other by little ridges. Slopes around 100% and over are not rare.

3.2 Soils

The soils evolved from the macigno formation are generally not deep, sandy loam or loamy sand in texture, acid, rich in organic matter in the upper when covered by forest. The horizon sequence is A-B-C with the B horizon that matches the properties of a Cambic horizon (according to the American system). These soils are mostly Cambisols of the dystric subtype according to the FAO legend of the soil map of the world. Sometimes the beginnings of leaching in A and of illuviation in B can be observed but they are not worth mentioning in the presence of Luvisols. These Luvisols, in some cases with hydromorphic features, are instead widespread downstream Stia on the medium terraces in the Casentino lacustrine basin.

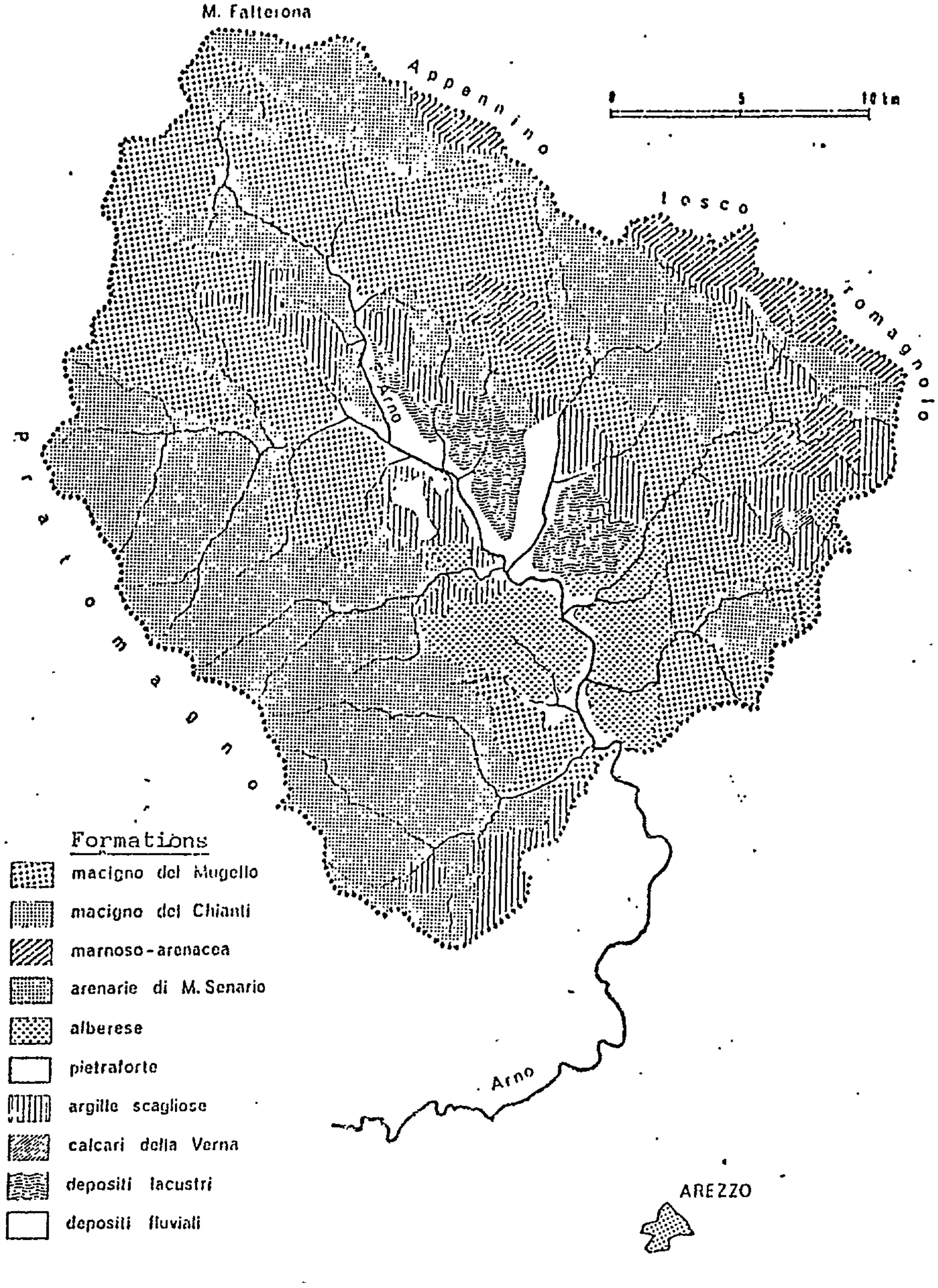


Fig.2 Schematic geological map of Casentino

Where marly limestones or clayey schists outcrop the soils are still Cambisols but have a quite different texture, going from clay loam to clay. They are rather shallow, with some coarse material, neutral or subacid. Water erosion takes place in many cases, so the soil profiles often appear more or less truncated. When cultivated these rather clayey soils give better results than the sandy types because the water balance until the dry month of August is more favourable due to the higher water retention capacity of the abundant organic and mineral colloidal particles.

3.3 Vegetation

The enclosed land use map (Fig. 3), prepared in 1981 by G. Baldini, along with Table I gives a rather precise idea of the situation as it was seven years ago. There have been considerable changes since 1980 especially concerning the cultivated land and the coppices. Many fields were abandoned over the last few years because of various difficulties (poor results, old age of the farmers) while the coppices, in particular those in public ownership, were gradually transformed into high stands. This is the case in all the higher area covered by beech (Pagus sylvatica). The woods near the summit of the ridges are of course protective ones and are able to defend against the most violent winds the forest situated below, which has a predominance of beech but also some elms (Ulmus montana), linden (Tylia sp.) and fir (Abies alba). At lower altitudes fir forests are frequent but in older plantations pines may be seen, especially Austrian pine (Pinus nigra). Various species of oaks characterise the forest and the coppice at medium elevation (Quercus pubescens and Quercus cerris overall) but the sweet chestnut (Castanea sativa) is also very common. This tree appears in two quite different situations. In the coppice it is cut every 10-12 years for poles for vineyards and other agricultural uses, or every 30-36 years for telephone poles. Near the farm houses and the villages it is still used today and was used much more in the past. The top quality produce was utilised by man also for normal nutrition and especially for pastry, the lowest quality as pork and sheep food together with oak acorns.

3.4 Hydrography

The Staggia stream basin covers a surface of 47.6 km^2. It is in the shape of an equilateral triangle with one of the sides placed along the Appennine watershed culminating in Mount Falterona (1,656 m s.l.) and the summit opposite it at its confluence with the Arno river at Stia, the most important built-up area in the district.

The name Staggia Stream refers only to the valley of the drainage pattern (a section of about 4 km between the height of 580 m s.l. and 448 m s.l.). It slopes steeply and is more hydrographic to the right than to the left with sporadic rocks appearing on the surface and a prevalence of detrital masses of limited stability. The course of the river is studded with numerous hydraulic works consisting of masonry barrages which serve to defend the bed from subsidence and to consolidate the lower slopes and to provide the factories in the valley with water. The stream's longitudinal profile (Fig.4), which is quite steep as compared to the moderate tenacity of the bed and its maximum capacity, slopes downwards by 3.6 to 2% from upstream to downstream.

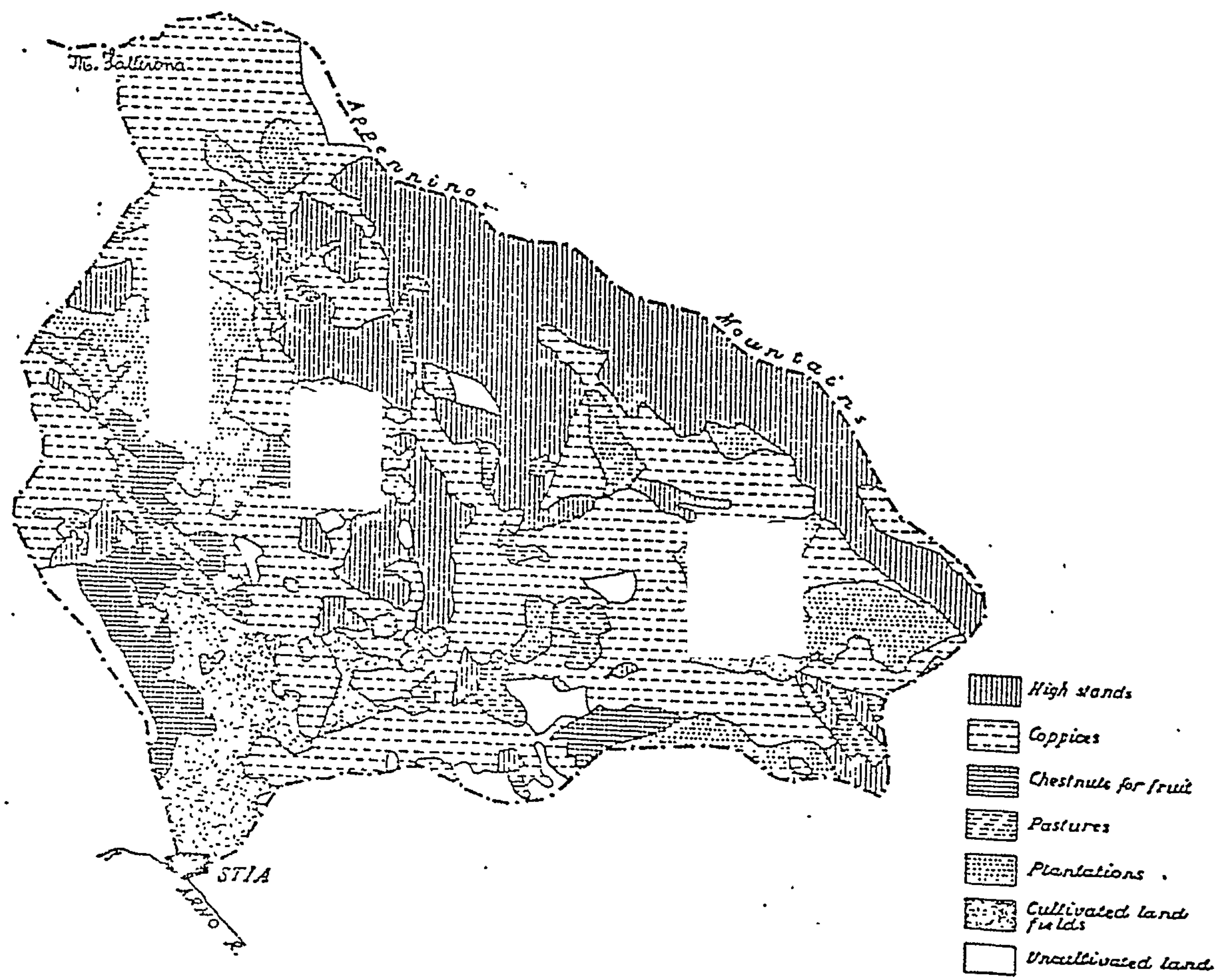


Fig.3 Watershed of the Staggia Stream : Land use (situation: end of 1980)

Table I

Land use (situation: end of 1980)

Catchment of the Staggia stream

Type	Surface in ha	%
Coppices	1,978	41.5
High stands	1,752	36.8
Chestnut for fruit	162	3.4
Young plantations (mostly coniferous)	365	7.6
Cultivated land	291	6.1
Pastures	88	1.8
Bare and uncultivated land	124	2.8
Total:	4,760	100

The drainage pattern that feeds the Staggia stream requires a brief description. As we said before, it constitutes only the system's catchment basin.

The major watercourses branch out along the main ridges corresponding to the course of the streams: Oia (Vadarello), Gorgone (Fossatone, Ruscello) and Rigaggiolo.

The Gorgone stream is the most important on account of the surface of its basin, its degraded conditions and the importance of the interventions carried out. It rises at Monte Cabrendo (1,450 m s.l.) and for a long distance it is flanked by the national highway that leads from Stia to Calla Pass (1,269 m s.l.), joining Tuscany to Romagna. The stream flows into the Staggia near Gaviserri and receives many tributaries, the most important of which are the Fossatone and the Ruscello.

Of all the phenomena that have occurred in the past in the basin, mention must be made of the great landslide on the slopes of Monte Tufone after heavy rainfalls from the autumn of 1926 to the spring of 1927. The Gorgone district is mainly a forest area and is located inside the century-old Casentino Forest, which is under very strict conservation regulations. Hydraulic-forestry planning has been implemented extensively; it concerns large consolidation works on areas which are liable to slide down.

The Ruscello stream, a tributary of the Gorgone, rises in the Appennine watershed at 1,350 m s.l. Its course is about 6.0 km long. Its basin is characterised by its wide agricultural areas, which have been almost completely abandoned and where erosive processes are now occurring on account

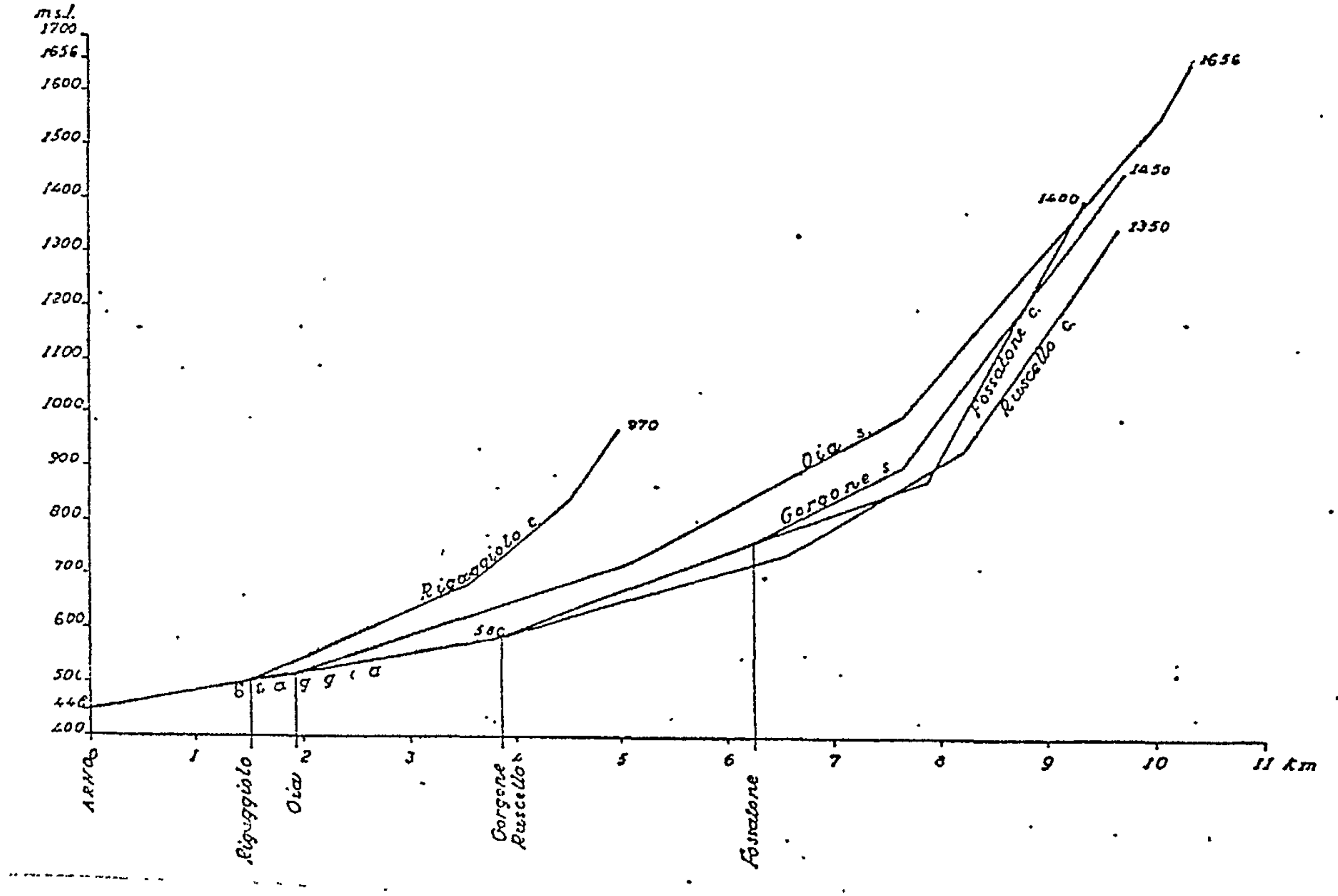


Fig.4 Watershed of the Staggia Stream : Longitudinal section of the watercourses

of the lack of utilisation of the soil, resulting in the degradation of layouts implemented for crop growing. In this basin, mainly forestal interventions have been carried out, apart from modest hydraulic works in the minor watercourses. Another tributary of the Gorgone stream is the Fossatone that rises at 1,400 m s.l. and is about 4 km long. It is also fed by numerous affluents. Countless, widespread hydraulic and forestal interventions have been carried out during the past decades.

The Oia stream has a total basin of about 12 km^2 (1/4 of the whole Staggia stream basin) with a considerable development of the drainage pattern. It rises in the spurs of Monte Falterona and flows into the Staggia near the village of Papiano, at 529 m s.l. About two-thirds of the territory falls into state-owned forest areas while the rest includes agricultural areas that have been largely abandoned or cultivated only sporadically. In certain tracts, its bed reached slopes of 17% and during flooding it was subjected to heavy erosion. After the construction of a series of barrages, those sections have achieved a satisfactory stability which extends to the slopes that flank it.

The Rigaggiolo stream is the smallest affluent of the Staggia. The basin consisted mainly of agricultural areas which are largely inactive nowadays. Even though it does not slope steeply, its bed has been worked on numerous times in order to safeguard built-up areas and their related roads of access.

3.5 Climate

With reference to the whole Casentino territory, of which Staggia stream forms part, the following climatic conditions occur.

The average annual temperatures vary from a maximum of 12-13 °C in the valley areas to 7-8 °C in the mountainous areas. During the cold months, the average temperatures drop respectively to +3 °C and -2 °C. However, these temperatures can reach extremes of +40 °C and -20 °C respectively.

According to weather reports dating back over 50 years, the Staggia stream basin's average rainfall measures an average of 1,350 mm and approximately 1,800 mm on the Appennine ridges and 1,100 mm at lower altitudes.

It rains mainly in autumn (peak season) and spring and to a lesser extent in summer (peak season) and winter. It only snows frequently at the highest altitudes. In the rest of the basin, the snowfall is not abundant and the snow cover is not prolonged.

Quite a correl-ted flow in watercourses accompanies the rainfall system. In fact, the streams are only really full on the occasion of heavy rainfalls and they are shallow during dry periods, given the limited water capacity of the geological formations. Perennial springs are few in number.

High temperatures and low rainfalls in summer characterise the Appennine peninsular climate. Two prevalent phytoclimatic areas can be identified in the basin: the Castaneum and Fagetum areas according to the Pavari-Mayr classification.

3.6 Heaviest short-lived rainfalls

In order to assess the size of hydraulic works, the technicians took into consideration the heaviest short-lived rainfalls, comparable to the concentration times of the competent basins. The sizes of the barrages, canals to collect downflows from slopes, etc. were based on these rainfalls. Under these rainfall conditions, erosion processes occur. They are diffused on the slopes and concentrated in the beds with an increase of solid flow in the currents. Quite often these rainfalls reveal landslides in progress.

Heavy rainfalls, which sometimes extend to many sub-basins of the Arno occur quite frequently.

For the past fifty years or so, a pluviographic station has been operating at Stia, enabling a detailed analysis of the heaviest rainfalls.

Listed below are the heaviest rainfalls occurring between 15' and 24h recorded up to 1980, whence it was possible to deduct the pluviometric possibility curve indicating the maximum rains necessary to calculate the forecast of the maximum flood flows.

Duration	15'	30'	1h	3h	6h	12h	24h
h (mm)	21.0	28.0	49.0	66.0	94.0	126.6	207.0
Year	1969	1928	1976	1959	1959	1966	1966

The fitting curve is $h = 39.8t^{0.49}$ with t expressed in hours.

In areas with a reduced surface (lower than 5 km^2), the curve changes as follows: $h = 60t^{0.5}$.

Of all the rainfalls recorded (even if they are not exceptional for the area) mention must be made of those in 1959 and 1966 that gave rise to considerable flooding. In the first instance, only the upper basin of the Arno was involved, whereas in the second case, it involved the whole of the Arno with disastrous consequences, as could be seen from the flooding of Florence.

There is very little data available on the above-mentioned rainfalls that took place in 1926 and 1927, causing heavy damages to the Staggia stream basin and valley areas. We know only the monthly rainfalls in a nearby village: they are, however, very reliable, significant figures, indicating the importance of the causes of the harmful effects. During the month of October 1926, 448 mm of rain was recorded, as compared to an average of about 200. During March 1928, rainfalls reached a total of 200 mm as opposed to an average of about 100 mm; therefore, rainfalls of more than double the average.

3.7 Flood flows

From an analysis of peak flows detected with direct measuring and calculations in various sections of the stream on the occasion of several heavy rainfalls, we deduced two formulas that express the maximum probable flows at a fifty-year frequency. For sub-basins covering less than 5 km^2 (concentration time equal to or lower than one hour), the unitary flood contributions can be deducted from the expression: $q = 20/S^{0.5}$ ($m^3/s.km^2$) whereas for basins covering over 5 but less than 100 km^2 the formula becomes: $q = 15/S^{0.5}$ (S indicates the basin surface expressed in km^2).

The engineers then checked whether existing works built in the past were still adequate for the flows deduced with these formulas; the results were always positive.

4. ECONOMIC AND SOCIO-POLITICAL CONDITIONS

The economic and socio-political events that have characterised Italian history during this past century have had a profound influence on the conditions of use of mountainous and hilly areas.

During the first half of the twentieth century, there was a high population and therefore intense exploitation of slopes, followed by their recent, almost total abandonment. The conditions of use of the soil (following on directives to make the greatest possible agricultural use, even in areas more suited to silviculture or pasture) have completely changed with the most recent phase of industrialisation in the country.

Whereas during the first period, interventions were required to lay out the land in order to obtain the conditions of stability necessary to guarantee the implementation of human activities, during the following period, the conditions of the lie of the land deteriorated. Nowadays further, and maybe more weighty interventions are scheduled, given the need for greater stability than was required when one could count on manpower for the rapid identification and elimination of any deterioration right from the start.

Defence requirements of sloping territories were associated with a direct interest in the defence of valleys, where there was the greatest urban, industrial, road and agricultural developments. The situation in this valley was affected by the accidents in the watercourse formation basins. The effects of this degradation on river courses, especially in those parts close to their mouths, and on the balance of the coasts, led to a revision of soil management methods and of activities aimed at their safeguarding.

A representative example of the above-mentioned situation is provided by the basin of the Staggia stream, located in the province of Arezzo in the Tuscan valley known as Casentino that forms the upper part of the Arno river, which flows into the Tyrrhenian Sea. It is a typical Appennine mountainous area, inhabited in the past by populations carrying out various activities, from agriculture to forestry and industry. During the past sixty years, it has been the object of important hydraulic-forestal layout interventions aiming at safeguarding the physical properties of the soil and at protecting it from the consequences of floods that have ruined the basin and causes damages downstream along the territories crossed by the Arno river.

Planning was oriented towards controlling the circulation of water in order to reduce erosion processes, to stabilise the slopes subjected to landslides and to reduce the torrential character of watercourses.

In order to define interventions and to fix the typology of works to be adopted, it was necessary first and foremost to identify the physical properties of places and the direct and indirect causes of phenomena that occurred, conditioning caused by situations and the feasibility of investments. That is, a general intervention plan was applied as opposed to a general plan that would have been difficult to formulate, given the mechanics of the continuously-evolving processes initiated. In fact, intervention criteria were determined and priorities, suggested by the gravity of situations and by the availability of funds, were established.

In the activities carried out, the technicians always followed a general concept of simplicity of schemes and work standards, avoiding going into minute details as the executive phase was implemented (as always occurs and should occur in similar cases) over long periods of time in an environment subjected to socio-economic changes and where the very configuration or lie of the lands is evolving. The planning criteria followed were formulated so that the territory in question does not extend very far and has very homogeneous distinctive characteristics.

It was considered a good idea to examine the crop rotation of this basin, assessing afterwards the results obtained with the widespread hydraulic-forestal interventions carried out, in order to make conclusions and learn lessons that could be extended to analogous activities in numerous other Appennine areas in our peninsula.

5. THE CAUSES OF DEGRADATION

After considerable layout operations, the Staggia stream still features conditions of erosivity ingrained in its morphology and geopedology. Since works have commenced, however, the situation has improved considerably, taking into account the socio-economic events that have characterised the past decades and which initially caused an increase in their agricultural areas (reducing woody areas), followed by their complete abandonment.

The general condition in the past of these Appennine basins flowing into the Arno can be deduced from documents kept in historic archives. In the upper course of the river no more than 6-7 floods per century were recorded until the sixteenth century. Afterwards, they became more frequent: 9 between the sixteenth and seventeenth centuries and 10 during the seventeenth century; 17 large ones in the eighteenth century and 20 during the first sixty years of the nineteenth century. The increase in floods could coincide with a period of wide-scale deforestation following on the abrogation of the regulations concerning the utilisation of woods. Before the eighteenth century, widespread yet organised programmed cuts did take place but with conservation criteria; but from the end of the eighteenth century, forest regulations disappeared, given the increasing timber requirements for building and especially for industries that were more and more widely diffused and which characterise the economic and social development of the nineteenth century.

Many of the wooded areas were then used for crop growing or pastures for cattle to meet the food requirements of a growing population; but no water regulations were laid down, thus increasing erosion and other phenomena.

Only at the beginning of the twentieth century was cultivated land laid out to make farming both possible and rational, as can be seen from the vast terraces built with dry walls.

The most harmful effects of the deterioration of the soil were felt downstream (in areas that had been reclaimed by means of drainage) on account of the overflowing of watercourses whose regimens were very much changed by quicker, higher flood flows and by increasing solid transport due to erosion in mountainous and hilly areas which then became the sites of more and more accidents.

The first hydraulic interventions to protect more fertile areas and urban and rural settlements were implemented in the valley. At the beginning of the nineteenth century, the first embankments were built along rivers, and they are still standing today. The expenses involved in these constructions were met by private citizens whose properties were threatened. The purpose of these embankments was to contain floods as far as possible and prevent solid deposits which could have caused overflowing, with the partial obstruction of the bed sections.

However, these interventions only partially lived up to expectations, that is, as long as the liquid and solid flows remained below certain values. Even recently their inadequacy has been noted on the occasion of heavy rainfalls.

Of all the basins supplying the Arno river, the Staggia stream basin has been subjected to the most interventions to combat impressive accident phenomena, erosions and landslides; more than any other basin, it has helped to stress the importance of defending the soil in the mountains in order to safeguard plans.

As was stated beforehand, in 1926 and 1927 following on a period of intense, prolonged rainfalls, heavy damage occurred in the Staggia stream basin, the effects of which were evident not only within the area but also downstream and along the Arno river as far as the village of Poppi, about 10 km from Stia, where they took on the proportions of a real calamity, on account of the large quantities of solid materials dragged along by the flow of the flood.

One of the most dangerous situations created on that occasion was the landslide on the slopes of Monte Tufone draining to the right in the Gorgone stream. The immediate effects were masses of material that obstructed the bed at several points and the flooding created a risk for the town of Stia. The flood transported large solid masses which seriously damaged homes, factories and minor construction jobs along the beds and road sections. Furthermore, the action of the water and solid material transported also caused heavy damage downstream from Stia, along the Arno river, removing bridges, houses and roads and creating deep erosion of the banks of beds and floods.

In the Staggia stream basin, but also in other areas, large numbers of layout interventions were carried out, giving rise to work that still continues today and which has been effective. As from the end of the twenties, the criteria followed in this case were adopted in other similar situations in a large part of the central-northern Appennines.

During the most recent and perhaps most serious flood ever recorded in the Arno basin (on the 4th November 1966), heavy damage occurred in the Staggia stream basin. It is likewise true that at the time rainfalls in the basin did not reach critical values, considering the concentration time of about 2 and a half hours; however, the duration and intensity of the rainfalls were quite remarkable, exceeding 200 mm in a period of about 25-26 hours. Existing layout works, some of which are very old, were subjected to a very strict test, without being heavily damaged.

6. INTERVENTIONS CARRIED OUT

6.1 Forestry works

In view of the causes of accidents that occurred and their consequences and given the forestal situation in the wake of the indiscriminate utilisation in the past, emphasis was laid on the reconstitution and improvement of woods. The forestal situation of the Staggia stream basin was as follows:

(a) areas requiring interventions, ha 3,492
(b) areas in a good state, ha 1,267

For the area under point (a) the following divison was made:

(a1) land to become wooded again and to be consolidated with accessory layout works, 1,385 ha

(a2) areas for which the enforcement of regulations was considered sufficient, 2,041 ha

(a3) woods to be re-established, 66 ha.

After the work has been completed in over sixty years time, the wood will cover approvimately 89% of the entire basin, against 55% before 1930. Therefore the forestal situation can be considered satisfactory, if not optimal inasmuch as there are two distinct, opposite aspects with regard to the use of the soil and the vegetative state of the woods in general.

In fact, in public property (that is, belonging to the State, Region and Local Authorities), about 64% (2,904 ha) of the entire surface features top-soils of considerable forestal and environmental value, formed and administered in the interests of the public. In these areas, an excellent coverage of the soil, efficacious for hydrogeological purposes, is ensured. Cultivated, uncultivated, barren and bare land, which are generally the main site for hydrogeological accidents, do not exist or are reduced to sporadic cases.

With the most recent forestal policy directives, quantitative and qualitative improvements have been made to forests in these areas, especially to copses and to reforestations. Whereas in the past, artificial systems were preferred in barren, uncultivated land, today there is a tendency towards the recovery of degraded woods with adequate silvicultural interventions.

State-owned woods occupy the largest area of the Staggia stream basin, which are the most exposed to the disgregating action of atmospheric agents that only an efficient forestal cover can keep within acceptable limits.

The main form of defence on State property consists of forests of tall trees, which occupy 1,600 ha, on their own or mixed with silver firs, Corsican pine and <u>Pseudotsuga</u> <u>douglasii</u>, together with resiniferous trees, beeches, chestnuts, oaks and maples, not to mention broadleaves.

The fir trees have been affected by various diseases with serious impoverishment, especially amongst high trees. For the other pure or mixed species conditions are satisfactory and excellent in the case of beechwoods.

Another form of defence of woods in this area are copses, largely defined as protection woods. They occupy the most inaccessible, degradable areas, including the steepest banks along watercourses for which they constitute the best possible defence.

The youngest reforestations were implemented thirty or forty years ago, but the majority of artificial systems date back to the pre-war period. At present, a great deal of thinning out is required but for various reasons, especially economic, nothing is done about it.

Sowable land and pastures are limited to a few tens of hectares and their maintenance is made necessary to safeguard the fauna (which abounds and has to be conserved for ecological reasons) and provide an incentive for tourism and recreation.

Uncultivated land, the total of which does not exceed several tens of hectares, is situated almost exclusively in barren, rocky areas, in which it is difficult to grow anything.

On private property, silvicultural conditions leave a lot to be desired. This is originally due to depopulation of the countryside that removed the necessary manpower for interventions and utilisations. Of the 1,850 ha forming this part of the woods, about 850 are copses whose vegetative state is mediocre on account of excessive ageing and too high density.

In recent years, the utilisation of private copses has been revived to a certain extent, but this takes place mainly in areas close to roads on account of the lower cost of the transportation of timber to the place of hauling. However, these interventions also concern areas where the vegetation is a fundamental element for hydrogeological balance, that is, on very steep land. These utilisations should be submitted to stricter controls where the woods protect the soil, possibly even with the enforcement of special regulations. Deforestation leads to the erosion and the creation of deep gulleys in the soil that soon becomes preferential watercourses. They often deepen leading to erosive processes that are sometimes irreversible. In these cases, one should rather provide an incentive for high trunk conversion with which the temporary coverage of the soil is better assured.

Systems implemented in the past thirty years have generally produced positive results. Land that once was a site for degradation or very advanced erosive processes has been completely recovered.

Reforestation has always been accompanied by preventive laying out of the land with modest, yet fundamental, stabilisation works such as steps, walls, reinforcements, embankments, trelliswork, etc. that facilitate the taking root of the plants and determine an efficacious control of water runoff along the surface.

6.2 <u>Hydraulic works</u>

Barrages were mainly used to hold streams back. They were used for the following purposes:

- to stop the lowering of the stream bed during excavation, creating fixed points;

- to consolidate banks and slopes by lifting the bottoms of beds;
- to reduce the speed of currents, consequently decreasing the quantity and dimension of transported materials.

Work on the bed, stopping its incision, combats fluviosubsidence erosion, which is the hardest to eliminate once it has occurred. In the case of the Staggia stream basin, only in certain cases was it a question of preventive interventions to avoid possible landslide accidents; but after the aforementioned floods, the situation demanded curative treatment of a process which was already under way and which had reached dangerous proportions.

Numerous barrages have been built in the basin and are still standing (Fig.5). Very little maintenance has been required to date but the age of almost all the works leads one to forecast that in the near future they will have to be made fully functional once again as their functional nature has somehow been compromised by rainfalls in the past (Table II).

Table II

Catchment of the Staggia stream
Masonry barrages built in the watercourses from 1930 to 1960

Watercourse	No.	Total height (m)	Mean height (m)
Staggia	14	61.90	4.40
Gorgone	12	47.60	3.95
Fossatone	4	7.90	2.00
Oia	16	42.00	3.80
Vadarello	2	7.80	3.90
Rigaggiolo	6	15.60	2.60
Ruscello	5	12.50	2.50
Total:	59	195.30	3.30

There are also about 3 km of embankments

Constructional and design criteria have changed in time. With the first interventions, they forecast barrages in stonemasonry and mortar with surfacing in view consisting of ashlars; very often, they built a counter-embankment downstream or a bed in masonry and side walls; almost always a curved shape - not an arch shape - was adopted.

Afterwards and in time, considerable structural simplification is achieved, without decreasing the validity and functional character of the work; they eliminated counter-embankments and beds in masonry which did not guarantee the barrage from undermining downstream. They followed the criterion of deepening the foundations to a maximum depth of 2-2.5 metres, having noted that this depth is sufficient to guarantee the river bed from deepening downstream on account of the head of water.

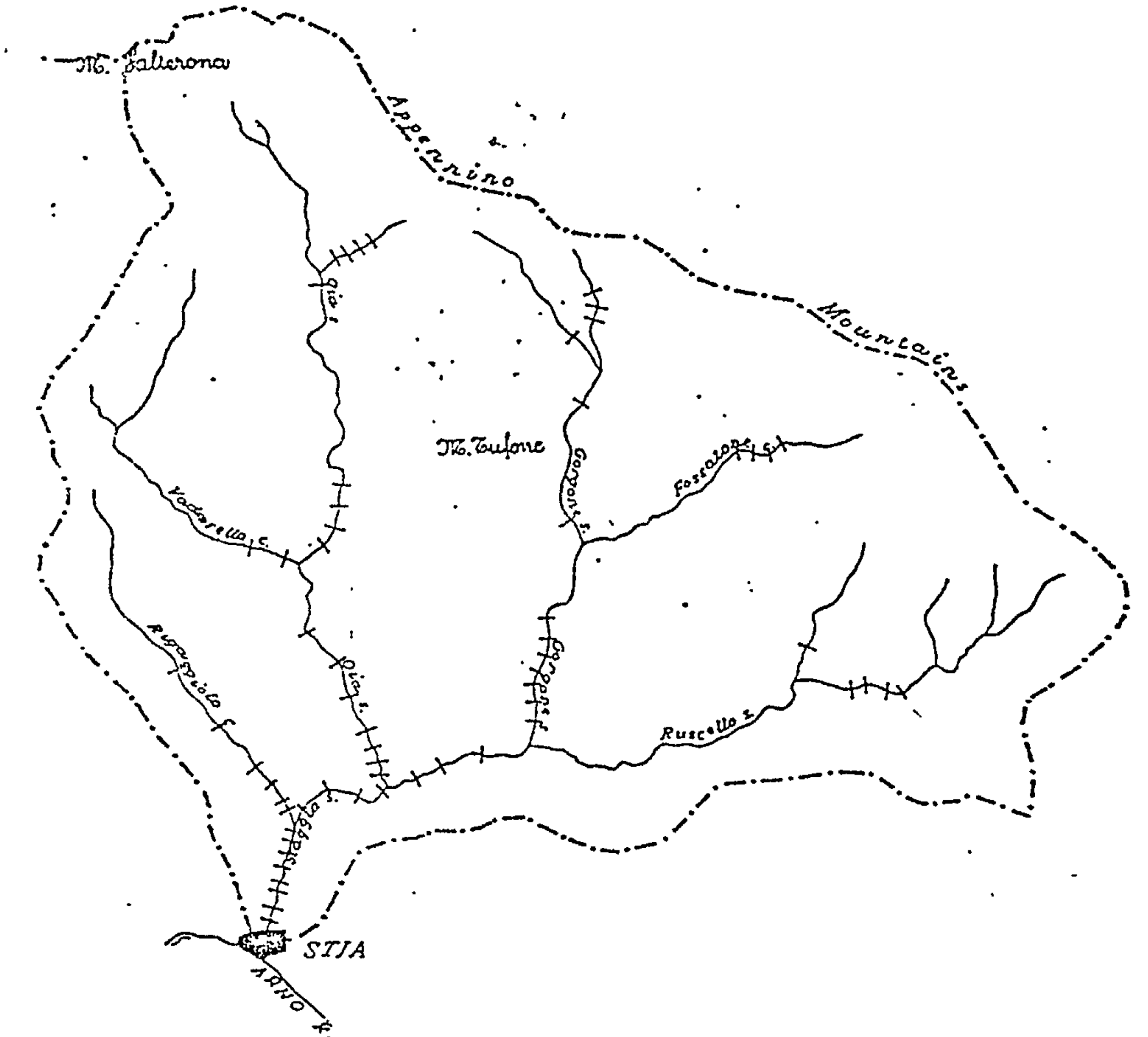


Fig.5 Watershed of the Staggia Stream : Barrages built from 1930 to 1960

A great deal of attention has always been focused on the dimensions of the weir so that it is always capable of containing the stream flow and therefore flood flows. This directive proved to be very important for the stability of work that can easily be ruined by means of the current turning its back when it is no longer contained in the weir area.

Another structural choice was a vertical face downstream whereas the upstream one was built in large steps. The crowning part was protected against erosion by the current and by materials floated by it with cut stone slabs.

In the project calculation they took as principal action the hydrostatic thrust carried out on the face upstream under conditions of maximum flood level anticipated and having checked the wall's stability against overturning.

Many of the works existing in minor watercourses are in dry stone masonry and have stood up very well, in the event of banks being subjected to movement.

7. CONSIDERATION OF RESULTS OBTAINED

Observation of the effects obtained with planning works is the only way to establish their validity and to deduce useful indications for future actions.

In fact, in this type of activity, it is of fundamental importance to avail ourselves of experiences validated in time, comparing effects obtained with the original forecasts. The lessons one learns are indispensible so as not to repeat errors and to establish the directives to follow when carrying out interventions with greater approximation. This is also connected to the need to work gradually so that the necessary changes can be made to the criteria assumed in the beginning.

In the Staggia stream basin, they worked quickly and on several parts at the same time; generally speaking, it is not advisable to follow this method as it can cause heavy rainfalls which would probably activate induced processes that are different from and greater than those one intends to combat. In the case in question, the gravity of the situation and its diffusion led one to proceed with huge interventions to eliminate as fast as possible the actions that had originally caused dangerous situations.

The effects of the works are quite evident for an observer covering the basin: forest coverage that was limited and ineffective is now lush and luxuriant; the beds show only sporadic conditions of instability that are no cause for worry. The action of the soil defence works also in the case of subsidence-prone areas has been successful.

There are no further remarks to be made based on direct observation, but it is possible to make an indirect remark concerning the general conditions of the Arno river between the confluence of the Staggia stream and the station measuring the flows and alluvial solid matter transport at Subbiano.

Firstly, there has been a considerable lowering of the depths of the river, initially very high and unacceptable on account of the imminent overflow danger, which must be largely attributed to the reduction of solid alluvial matter coming from degraded areas of the tributaries.

Hitherto invisible rocky layers emerged from the bottom of the bed and the foundations of structures such as bridges and embankments built several years ago appeared on view. At the confluence of the larger tributaries, there was an obvious increase in depth, that goes back upstream along the beds and also determines the deepening of the bottom of the bed which in some cases has caused collapse of the banks.

A decrease in the transport of solid matter materials was detected at Subbiano station; this can be deduced from the silt flows: from 1958 (the first year in which measurements were taken) to 1972 (up to which data is available) it can be quite clearly seen that the specific silt flow per annum is decreasing in quite a significant way; it has passed from an average of 565 tons/km^2 to 360 tons/km^2 per annum corresponding to an average liquid flow of approximately 1,300 mm. It is also interesing to emphasise that in 1966, the year in which heavy rainfalls and exceptional floods occurred, silt transport was 466 tons/km^2 whereas the following year it dropped to 93 tons/km^2.

One cannot say that the works carried out have produced tangible effects also on liquid flows; the average annual flow coefficient recorded an average of 0.6 from 1930 to 1950 and then dropped slightly afterwards, is now tending to increase slightly; in 1972 it was a high as 0.62, still referring to average rainfall compared to the previous period. The increase is not significant, but one must, however, conclude that interventions did not modify and influence dispersion effects considerably.

Nothing, however, can be said about flood flow regimens as there are not sufficient elements available to express a definitive opinion.

Nowaways the Staggia stream appears to be well covered in vegetation, which is also proof that it has reached soil stability. There are very few bare, badly-surfaced areas, such as the slopes of Monte Tufone at the time of its landslides in 1926-27. Even today, potentially unstable areas do exist, but they are well controlled by works carried out and in time their degree of stability should increase.

The problem that arises today is not so much a question of the completion of interventions programmed at the time and which have to be carried out in any case, but more a case of the maintenance of the effectiveness of works already implemented. Maintenance is carried out in time as a rule but, as time passes, situations worsen on account of the age of works carried out many decades ago, which are affected by their age and heavy rainfalls. The large number of minor construction jobs represents a large commitment for the public administration responsible for their preservation, but if one wants the beneficial effects to remain, maintenance works are indispensible.

L'IMPACT DE L'AMENAGEMENT DES FORETS SUR LA PROTECTION DES SOLS ET DE L'ENVIRONNEMENT AU MAROC

par

M. AZEBA et I.A. FILALI
Service des Eaux et Forêts et de la Conservation des Sols
Al-Hoceima, Maroc

1. INTRODUCTION

Le Rif, région montagneuse fortement accidentée, est sujet de manière continue et perpétuelle à des phénomènes érosifs multiples et très complexes.

Ceci est davantage aggravé par le caractère vulnérable du couvert végétal et des sols, par l'agressivité climatique (caractère intense et irrégulier des précipitations pouvant atteindre en altitude une pluviosité moyenne annuelle de 1.500 mm), par la densité élevée de la population et par la dispersion de l'habitat.

Ainsi, et comme l'ont précisé à juste titre PASCON et al., 1983, dans le cas précis d'une petite vallée méditerranéenne du Rif, le raisonnement élaboré pourrait aisément être généralisé à l'ensemble de la région comme suit:

- l'explosion démographique crée un besoin sans cesse croissant en terres nouvelles de culture, et de bois de feu, se traduit par une augmentation du cheptel et par conséquent des besoins plus importants en terrains de parcours. Ainsi, incontestablement, il y a donc à moyen et long terme surexploitation, surpâturage, et par la suite, diminution des surfaces utiles et détérioration du milieu environnemental, conséquence toute logique de la progression des méfaits de l'érosion, par suite de la destruction et de la stérilité des terres.

C'est ainsi que le présent rapport, dans le cadre du CAR/PAP, se propose de déterminer les causes de dégradation avec les conséquences qui en découlent, d'identifier ces phénomènes érosifs et de les analyser par une évaluation correcte des besoins en conservation des sols, d'exposer les dispositions prises et actions effectuées à ce sujet et de faire ressortir enfin le rôle de la couverture végétale dans le maintien de l'équilibre écologique et environnemental, tout en terminant par l'ébauche de quelques propositions et perspectives susceptibles de contribuer à l'appréhension et à la maîtrise des problèmes de l'érosion.

Toutefois, il est important de signaler que le véritable problème est avant tout d'ordre social. Aussi, est-il impératif de concevoir tout projet d'aménagement à l'échelle de l'unité humaine (fraction ou commune), d'associer les populations locales à son élaboration et surtout de l'insérer dans le cadre global intégré, d'une politique d'aménagement du territoire.

2. RENSEIGNEMENTS GENERAUX SUR LE PROBLEME (Fig. 1)

2.1. Description du couvert végétal

Deux domaines floristiques distincts s'individualisent dans la région concernée (Ben Abid 1982, Fig. 2):

A. Domaine floristique méditerranéen atlantique:

Il s'agit du domaine de prédilection par excellence des subérales marocaines, avec la prépondérance des espèces atlantiques.

Des sept secteurs qui le subdivisent, trois seulement nous intéressent dans le cadre de la présente étude:

(i) Le secteur ibérique (composé en quatre sous-secteurs):

se caractérise par une flore essentiellement ibérique et ouest-méditerranéenne, à base de chêne liège et de bruyères, Erica australis et Erica Scoparia;

Des espèces relictes, il convient de noter la présence d'Erica Ciliaris.

(ii) Le secteur rifain:

Concerne la haute montagne, avec un rôle plus atténué des bruyères et une abondance marquée des génistées.

Dans ce secteur, on peut distinguer:

- un sous-secteur du Rif calcaire, caractérisé par la présence des seules sapinières du Maroc (Abiés pinsapo var. marocana);

- un sous-secteur du tisirène-Tidighine qui abrite les cédraies rifaines (Cédrus atlantica).

(iii) Le secteur du haut ouergha:

La subéraie peu abondante cède la place aux pinèdes, oléastraies, callitriaies, coniféraies;

B. Domaine floristique maurétano-méditerranéen:

Englobe le nord-est et fait apparaître un cortège floristique méditerranéen adapté aux conditions de sécheresse, à base de thuya et de pin d'Alep en particulier.

2.2. Causes de dégradation et déforestation

L'état actuellement dégradé d'un certain nombre de zones forestières jadis denses et salutaires, ne pourrait trouver d'explication que dans un contexte historique avant tout.

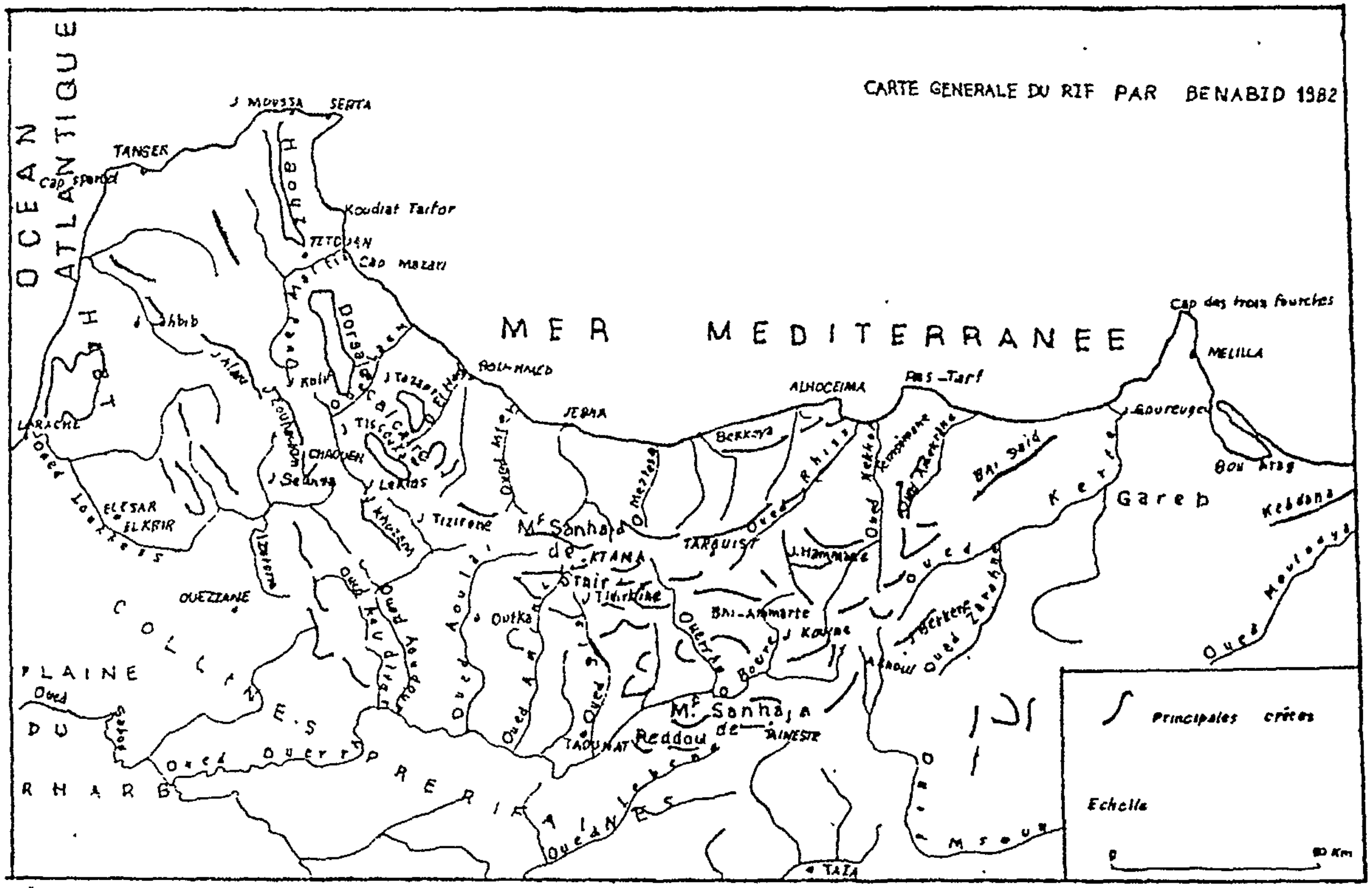
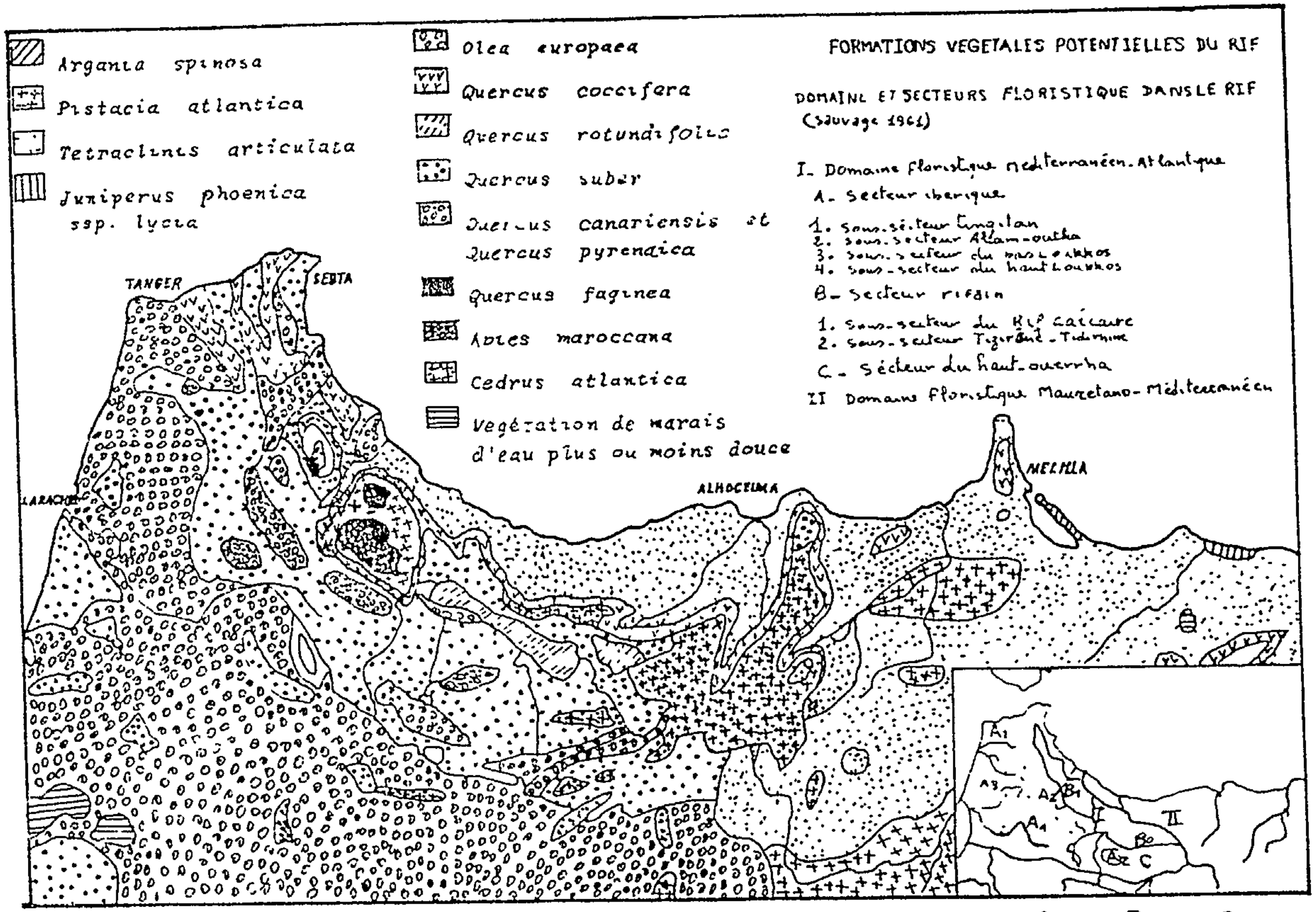


Fig.1 Carte générale du Rif



Selon BENABID

Fig.2 Formations végétales potentielles du Rif

En effet, des pratiques destructrices poussées à l'extrême étaient "monnaie courante" chez les colons espagnols, dont le seul but était le profit maximum sans se soucier guère des problèmes de possibilités, de régénération des forêts ou autres. Des prélèvements massifs et intensifs ont ainsi affecté, à la fois, plus-value et capital (Drissi, 1976, Ben abid, 1982).

Des scieries "tournaient" continuellement en pleins massifs forestiers, à la suite de coupes systématiques entreprises sur cèdre, sapin, pin et chêne liège, à la recherche de bois d'oeuvre de qualité, de charbon de bois et de liège.

D'ailleurs, tous les "gros calibres" ont pratiquement disparu en ce qui concerne le bois d'oeuvre.

D'autant plus que la politique forestière de l'époque était assez permissive (Pascon et al., 1983).

Ce n'est en fait que depuis l'indépendance que la présence forestière a été renforcée et des dispositions énergiques ont été prises pour une gestion plus rationnelle des forêts.

Cependant, l'explosion démographique continue à exercer une pression assez forte sur la forêt qui se manifeste essentiellement par:

L'habitat:

Le caractère assez dense et surtout éclaté de l'habitat rural, constitue une source incompatible avec le milieu et par conséquent l'élément principal de déstabilisation de celui-ci.

En effet, l'état des installations souvent anarchiques constitue le début du déclenchement d'une opération d'extension progressive en taches d'huile, au détriment du couvert végétal, avec tout ce que cela exige comme terrains de culture et chemins de liaisons à créer, avec le réseau de pistes existant.

Ajoutons également les prélèvements massifs qui s'opèrent en ce qui concerne les sables nécessaires pour ces constructions et qui ont lieu généralement au niveau des côtes, ce qui dénature et affecte sérieusement ces sites.

Les défrichements:

La perpétuelle recherche de terrains de culture par les populations riveraines conduit à des défrichements intenses (557 ha/an, selon Zitan, 1985, pour la province d'Al-Hoceima).

Ces terrains ainsi exploités et qui s'appauvrissent après quelques années sont alors abandonnés et exposés aux méfaits de l'érosion, au profit de nouvelles tentatives toujours itinérantes et destructrices, d'actions de défrichements.

Le parcours:

L'exercice irrégulier et non réglementé du parcours porte atteinte incontestablement au dynamisme et à la régénération des forêts. Ceci est

d'autant plus accentué en période de sécheresse, particulièrement où l'on assiste à des affluences accrues du cheptel en forêt, qui demeure un refuge utile et sûr.

De même, il est important de signaler les pratiques courantes d'étêtage en hiver (écimage des chênes), ou encore la casse directe des branches (parcours "suspendus"), pour les mettre à la portée du bétail.

Les incendies:

De tous les vecteurs de déprédation du milieu, l'incendie demeure le facteur le plus dangereux de par sa brutalité, l'ampleur des dégâts causés et des surfaces embrasées. Surtout quand on sait que les forêts rifaines, comme dans toutes les régions méditerranéennes, présentent une plus grande sensibilité vis-à-vis du feu, en raison de la sécheresse estivale assez marquée et d'essences fournies et inflammables.

Les mises à feu souvent dues à l'insouciance sont parfois provoquées par les populations en vue d'acquisition de terrains à des fins de mise en culture.

Les coupes délictueuses:

- bois de combustion: la consommation de cette catégorie de bois atteint des chiffres records par endroits. Ce qui dépasse les potentialités des matorrals existants: 13 à 17 t/foyer/an selon une étude entreprise par la section des inventaires et aménagements (service forestier d'Al-Hoceima 1981, 1985).

- coupes de bois d'oeuvre: celles-ci sont localisées dans les grands massifs résineux, particulièrement la cédraie. Ces prélèvements sont estimés à environ 1000 m^3/an.

2.3. <u>Impact de la dégradation sur le sol et l'environnement</u>

Les divers et multiples agents de dégradation précités engendrent et développent à l'évidence un processus érosif sans cesse croissant sous toutes ses composantes et ses formes, et dont les conséquences sont particulièrement dévastatrices:

- perte de la terre arable: la source principale du revenu, mise à nue, est ainsi ruinée et rendue stérile et inerte. Les superficies délaissées progressent alors au fil des ans, et la tâche délicate et ingrate de reforestation exige énormément de patience et surtout d'efforts soutenus et continus.

- altération des infrastructures:

  - barrages: la durée de vie utile des retenues est sérieusement compromise, en raison de l'importance des carriages qui s'y déversent surtout que les investissements consentis pour la réalisation de ces ouvrages sont considérables.

  - réseau routier: celui-ci est généralement envahi et détérioré par des masses solides assez importantes.

- les risques des inondations par suite, de l'absence d'infiltration des eaux: en effet, l'écoulement superficiel devient important et ses conséquences désastreuses: engravement des ports maritimes, envasement des terres cultivables, destruction et endiguement des canaux d'irrigation et prises d'eau agricoles;

- affectation des nappes phréatiques, des sources, des puits qui s'amenuisent;

- aspect désolé du paysage;

- faune en nette régression par suite de la destruction des divers biotopes.

Ainsi, le rôle du couvert végétal se fait sentir à tous les niveaux. Il est à la fois régulateur climatique, hydrologique, stabilisateur, anti-érosif, environnemental et hygiénique. Mais il est surtout le facteur primordial à l'équilibre, au bien-être et à l'épanouissement de l'homme. De même, il constitue un capital sûr dont les intérêts demeurent acquis aux générations futures.

2.4. Concept d'une approche intégrée

Tout le mal dont pâtit la forêt et le milieu en général, vient du fait que les divers protagonistes considèrent qu'ils constituent une ressource inépuisable et que seul l'intérêt immédiat prime.

C'est pourquoi un vaste effort d'information et de vulgarisation des populations est toujours indispensable, en vue de les sensibiliser, au mieux, sur la nécessité de conservation, de sauvegarde du couvert végétal et surtout d'exploitation rationnelle et adéquate du milieu, tout en faisant ressortir les menaces et conséquences de toute déstabilisation.

Ainsi, tout projet de quelque nature que ce soit doit tenir compte du facteur social, lequel demeure capital et essentiel. Celui-ci doit être associé à toute planification, laquelle doit être menée et réalisée à chaque fois à l'échelle de l'unité humaine.

En effet, il convient d'amener les populations locales à une participation directe à la mise sur pied du projet, et à une assocation aux efforts de la manière la plus utile.

Ceci les conduira à adhérer aux interventions ainsi projetées, voire même les adopter.

De ce qui précède, il en découle que tout objectif doit aboutir à l'établissement d'un plan d'aménagement harmonieux avec des interventions adaptées, précises et bien réparties dans le temps et dans l'espace en vue d'une exploitation adéquate du milieu tout en tenant compte des intérêts vitaux des populations rurales.

2.5. Données sur les conditions naturelles de la zone de mise en oeuvre du projet (schéma directeur, projet MOR 71.536, 1977)

Le bassin versant du Neckor en amont du barrage, sur une superficie de 78.000 ha, se situe dans la partie orientale de l'ARC rifain. Il s'ouvre sur la Méditerranée par une large plaine alluviale, à l'est de la ville d'Al-Hoceima (Fig. 3).

Sur le plan géologique, il s'agit de "formation sédimentaire du type schisteux et marno-schisteux, tendres, fracturées et manquant de cohérence..." (Fig. 4).

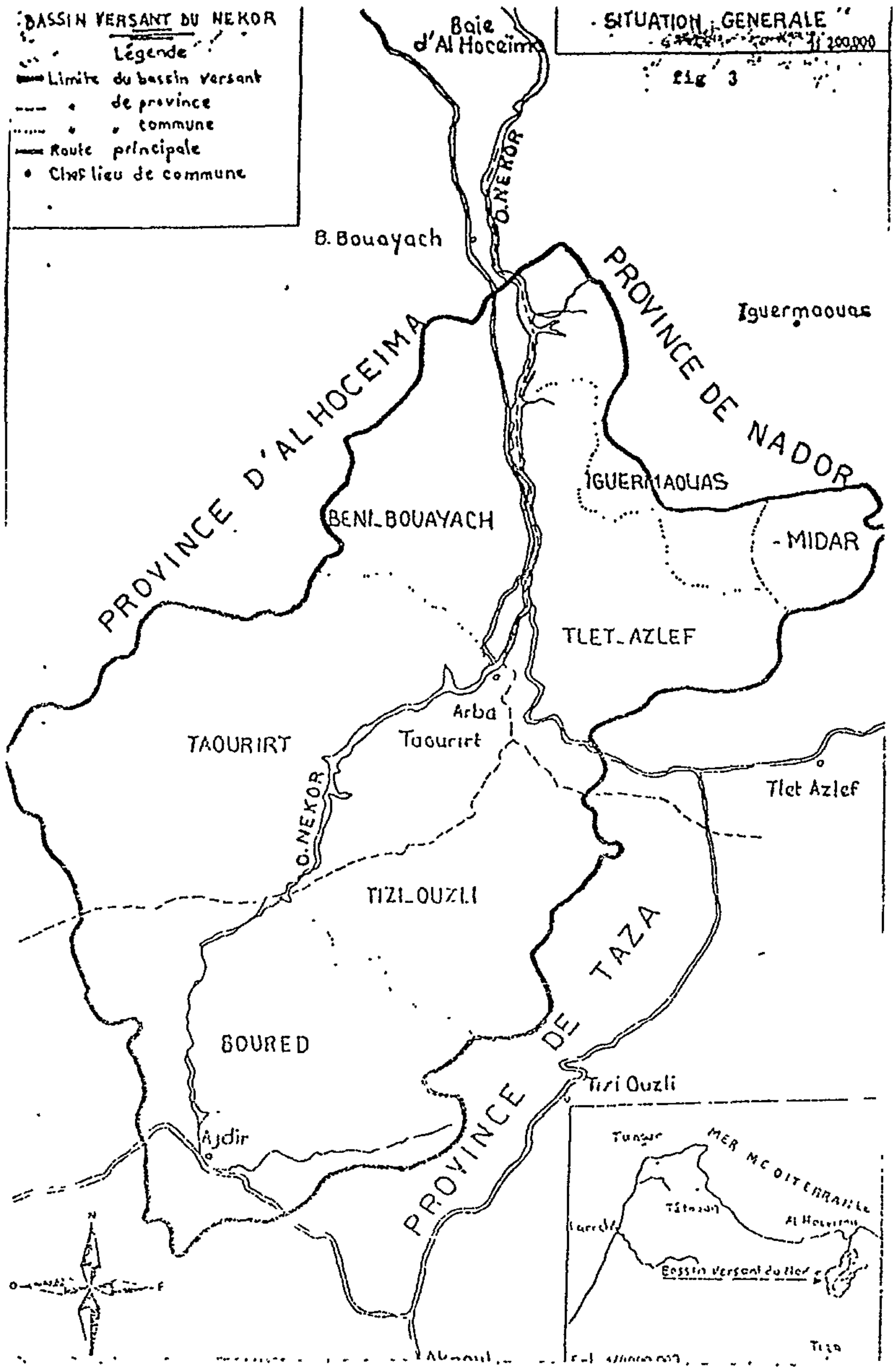


Fig. 3 Bassin versant du Nekor - Situation générale

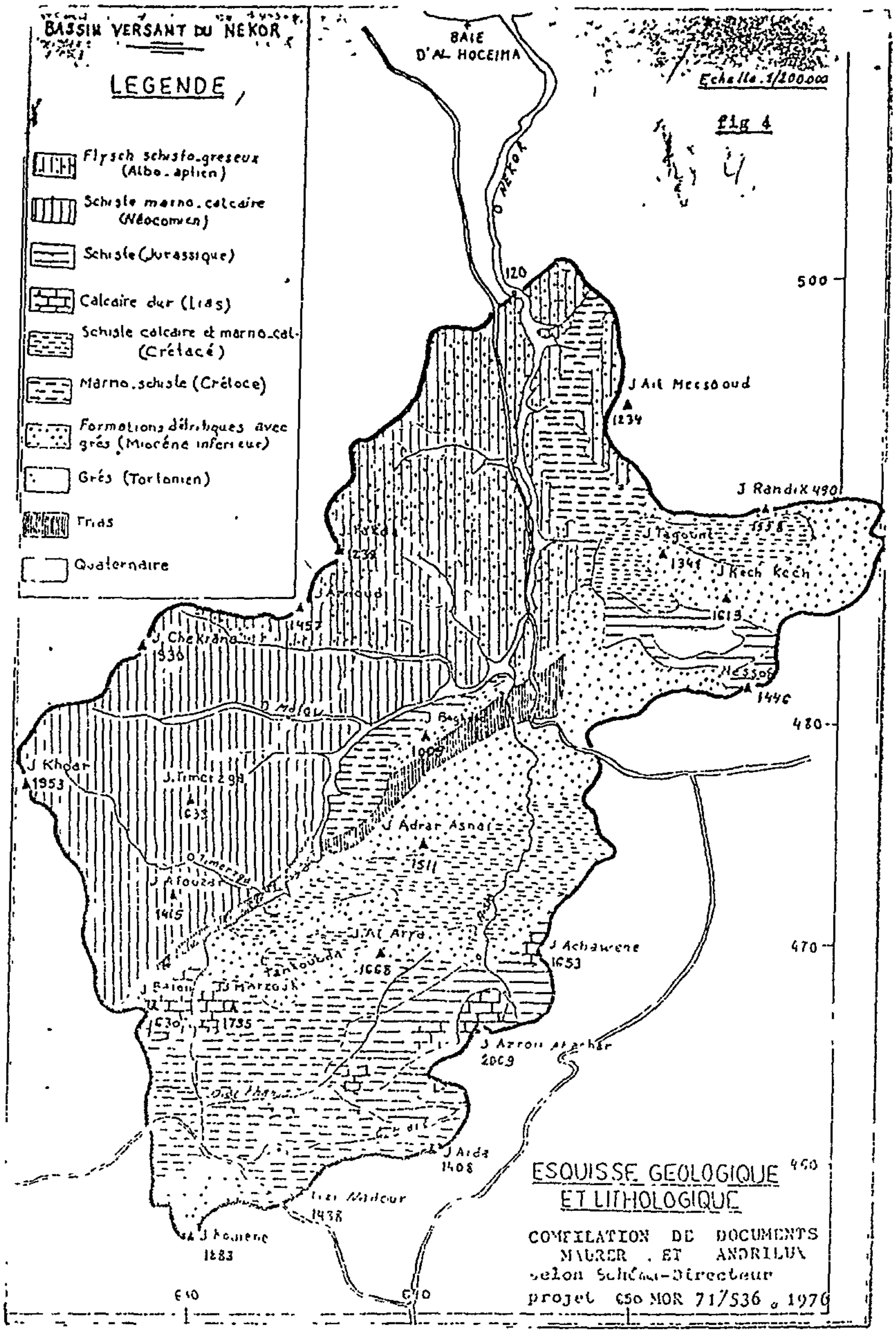


Fig. 4 Bassin versant du Nekor - Esquisse géologique et lithologique

Pour ce qui est du relief, il est fortement accidenté. Le lit du Neckor, au niveau du site du barrage est à 120 m d'altitude. Le point culminant atteint 2009 m.

La courbe hypsométrique fait ressortir que:
- 55 % du B.V. se trouvent au-dessus de 1.000 m
- 10 % du B.V. se trouvent au-dessus de 1.500 m.

D'autre part:
- 40 % du B.V. ont des pentes supérieures à 50 %
- 18 % seulement ont des pentes inférieures à 20 %.

Quant aux sols, il sont dans la majorité des cas, peu évolués, très superficiels, à l'exception des quelques rares terrasses issues de dépôts récents.

S'agissant du climat, il est de type méditerranéen à hiver doux, peu pluvieux et à été chaud et sec (Figs. 5 et 6). M=24,5°C (août), m=12,8°C (décembre).

La pluviométrie moyenne annuelle dans la basse vallée du Neckor se situe autour de 300 mm.

Dans la haute montagne, cette pluviosité peut atteindre 1000 mm. De même que les enneigements y sont fréquents.

Par ailleurs, les types de formations végétales identifiés correspondent à deux bioclimats:

- le bioclimat à oléo-lentisque caractérisé par un faciès aride et un cortège floristique thermoxérophile à base de thuya.

- le bioclimat à chêne vert au-delà de 1000 m d'altitude avec des conditions montagnardes plus froides et moins arides.

En outre, les ripisilves occupent une large place dans les délaissées d'Oued à base de saules et de peupliers blancs.

Enfin, c'est ainsi qu'en raison des conditions lithologiques précitées, aggravées encore davantage par une absence quasi-totale du couvert végétal (2%), par une topographie très mouvementée, et par une agressivité climatique particulièrement active, que l'érosion s'en trouve alors généralisée dans tous ses aspects et avec toutes ses composantes.

3. METHODOLOGIE APPLIQUEE

Toute approche d'évaluation exige inévitablement de recourir à un classement des terres relativement adéquat, stade nécessaire devant aboutir à l'objectif escompté.

Ce classement tient compte du relief (expositions, pentes), du substrat, des propriété physico-chimiques des sols, de l'agressivité climatique, de l'état et de la nature de la végétation existante, du degré d'érosion active et potentielle ainsi que de l'utilisation actuelle des terres.

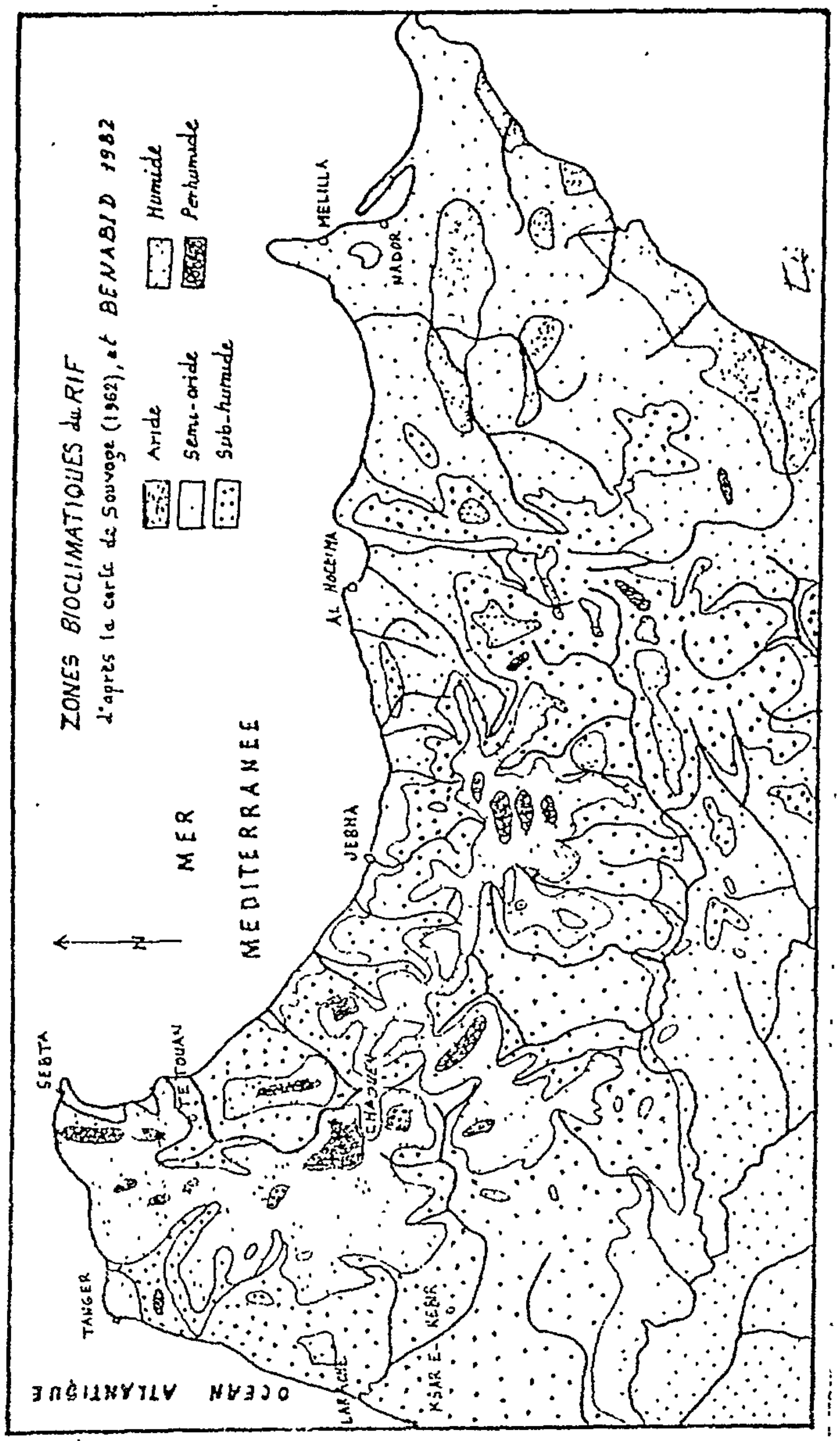


Fig.5 Zones bioclimatiques du Rif

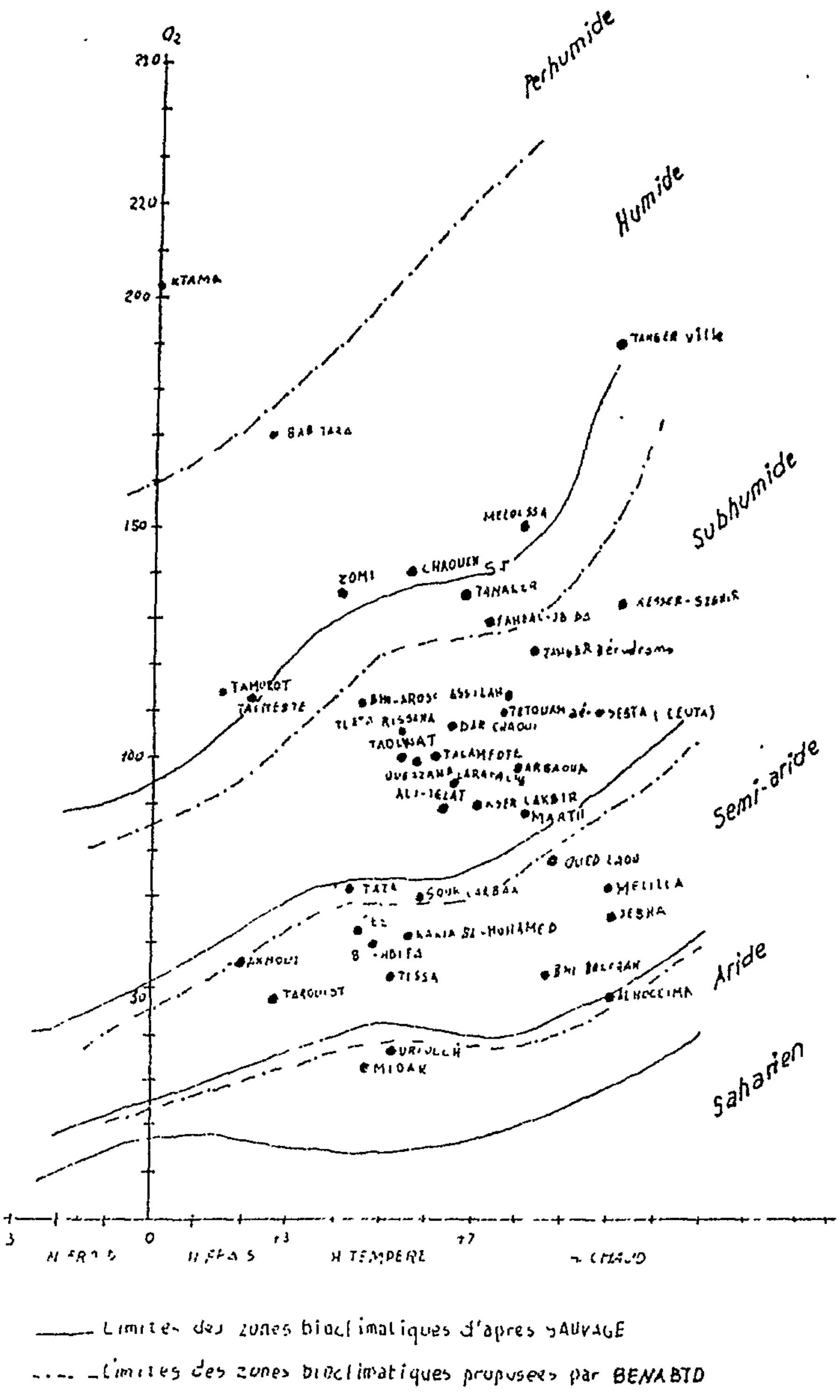


Fig. 6 Peuplements forestiers du Rif
Climagramme du quotient pluviothermique d'Emberger, modifié par Benabib.

Cette classification revêt toutefois pour le cas particulier du Neckor un caractère assez lâche dû aux conditions sociales singulières, ce qui lui confère un aspect purement local.

Les différentes classes de terres sont mentionnées en annexe (Viertmann, projet mor 71/536, 1977).

Quant à l'analyse des principaux types de végétation existants, elle s'est basée sur les aspects physionomique, dynamique, phyto-sociologique et pastoral (Stefanesco et al., 1975).

L'élément essentiel de cette méthode repose sur l'établissement de relevés phyto-écologiques. Ce qui a abouti à la définition des groupements végétaux et à arrêter les séries de dégradation qui intéressent la plus grande partie des terrains du bassin versant du Neckor.

Ce qui explique d'ailleurs le fait que les interventions biologiques (reboisement en particulier) occupent une place de choix parmi les recommandations arrêtées par le schéma-directeur d'aménagement du bassin versant du Neckor, étant donné le rôle de telles actions sur la conservation des eaux et des sols.

Ces actions intéressent en priorité les terrains les plus menacés par les effets néfastes de l'érosion.

Ainsi, des efforts importants ont été consentis dans ce sens. Ce qui a porté le taux de boisement de 2% à l'état initial, à environ 12% à l'état actuel.

Par ailleurs, étant donné la croissance lente des essences forestières, l'impact anti-érosif de telles interventions exige un temps de réponse très long.

Il y a lieu d'associer ce type d'action à chaque fois avec des travaux d'ingénierie dûment bien conçus.

Toutefois, compte tenu de l'importance de l'arboriculture dans la région qui constitue par ailleurs la base des spéculations agricoles existantes et l'essentiel des activités rurales (amandier et figue notamment), le recours aux interventions arboricoles, s'avère nécessaire et vital.

En effet, l'introduction massive à base d'espèces fruitières se justifie par le fait que les populations locales ont tendance généralement à émettre certaines réserves à l'encontre des reboisements jugés quelque peu restrictifs par ces mêmes populations en raison des mises en défense engendrées sans qu'il y ait un quelconque apport direct et immédiat pour les riverains concernés.

De ce fait un programme très important est élaboré annuellement en fonction des désirs des agriculteurs et qui consiste en la distribution gratuite de quantités considérables de plants fruitiers dans le cadre de subventions en nature: amandier, olivier, figuier, noyer, pommier, prunier, etc.

Ceci entre également dans la stratégie de vulgarisation et de sensibilisation des agriculteurs pour une utilisation rationelle des terres.

L'encadrement technique est asssuré le long de cette opération par un personnel qualifié en vue d'une réalisation parfaite de la préparation du sol, prise en charge entièrement par les propriétaires bénéficiaires.

Ainsi le recours à l'arboriculture, malgré son effet anti-érosif atténué (perte de feuillage, faible densité) constitue un compromis indispensable et un point de "passage obligé" pour obtenir l'adhésion totale et la participation effective des agriculteurs.

Reste à assurer la combinaison adéquate de cette action fruitière avec un réseau de banquettes, gradins ou impluviums, bien conçus pour obtenir l'efficacité anti-érosive recherchée.

Dans le bassin versant du Neckor, toutes les conditions naturelles, en premier lieu le relief et la nature du sol, sont réunies pour porter l'intensité des phénomènes d'érosion au plus haut degré.

Les agriculteurs ont parfaitement conscience de cette situation et certaines techniques de conservation des sols sont déjà appliquées traditionnellement.

Il n'en demeure pas moins que les besoins en terres de culture ont conduit à travailler des terres sur lesquelles des limitations sévères s'imposeraient pour réduire au minimum les pertes des sols, alors qu'un processus accéléré de dégradation est installé.

Aussi, d'importantes interventions ont déjà été proposées, portant sur les types de traitements suivants:

<u>Les aménagements agricoles</u>:

Dans les zones de cultures annuelles en sec:

- sur substrats perméables: introduction de plantations fruitières (amandier, figuier, olivier);

- sur substrats peu perméables: installations de vigne et de cultures fourragères.

Les techniques de préparation du sol sont ainsi ajustées au degré d'érosion rencontré.

Dans les zones d'arboriculture extensive:

- intervention dans un but d'intensification et souvent de rajeunissement des plantations fruitières existantes (notamment par des techniques de surgreffage de variétés plus tardives et mieux productives en ce qui concerne l'amandier).

<u>Aménagements pastoraux</u>:

Des techniques portant sur la création de prairies permanentes, d'installation de bandes fourragères ou de cordons végétaux ont été développées assez largement.

Par contre, leur mise en application s'est révélée difficile dans le cas particulier du Neckor, en raison de ses conditions rudes.

D'autre part, en dépit des effets largement positifs de ces interventions biologiques, il n'en demeure pas moins que leur quantification reste encore au stade expérimental.

Quant à l'impact sur l'environnement, le rôle régulateur au sens large du reboisement n'est plus à démontrer.

Par ailleurs, de par sa création, il constitue une réserve de fait, et par là-même, un abri et un refuge utiles qui assurent quiétude et prolifération pour la faune sauvage.

L'existence, en effet, au niveau de la zone côtière de toute une série de périmètres de reboisement en "chapelet" confère à cette zone un intérêt cynergétique et ornithologique hautement significatifs: le secteur côtier et l'arrière-pays du littoral (principalement au niveau de la province d'Al Hoceima) constituent un enjeu de protection de haut niveau international sur les plans écologiques et scientifiques.

Cette zone, en plus de son caractère giboyeux, abrite des populations d'oiseaux inscrites sur la liste rouge des espèces menacées d'extinction à l'échelle du bassin méditerranéen dont notamment le balbuzard pêcheur: Pandius haliaetus (Béture Setam, 1985).

Analyse socio-économique

La mise en oeuvre de mesures de conservation des sols, incorporées à la gestion des terres de cultures pastorales et forestières, dépend étroitement de l'attitude de l'exploitant de cette terre.

De ce fait, l'efficacité et la réussite de toute intervention sont subordonnées à l'accord préalable et à la collaboration totale et effective des agriculteurs.

C'est dans cette optique qu'un travail de longue haleine est entrepris au niveau des sous-bassins versants, dans le cadre des travaux de planification et programmation, pour une meilleure vulgarisation et une plus grande sensibilisation des populations aux problèmes de l'érosion.

L'enquête socio-économique ainsi engagée englobe plusieurs aspects:

- statut familial et caractéristiques sociales;
- facteurs économiques: pratiques agricoles, tailles et structures foncières, itinérance des cultures...;
- attitudes et désirs.

L'identification de la nature de l'intervention à mener et sa programmation sont ainsi arrêtées au vu du résultat de l'enquête en question.

4. RESULTAT DU PROJET

4.1. Classement des bassins versants d'après le niveau de dégradation des forêts et des sols.

Le tableau ci-après fait ressortir les données relatives aux 3 bassins versants étudiés au niveau du Rif (Pasket, FAO, 1981)).

De ces trois bassins versants, le Neckor est le plus affecté par l'érosion (Figs. 7 et 8).

Caractéristiques principales

B. Versant / Caractéristiques	Neckor	Loukkos	TLETA
- Nom du barrage	Abdelkrim Al Khattabi	Oued El Makhazine	Ibn Battouta
- Volume du réservoir ($10^6 m^3$)	38,5	155	43
- Superficie (Km^2)	780	1820	182
- Pluviométrie moyenne (mm/an)	340	1090	790
- Ruissellement (mm/an)	119	575	327
- Débit moyen (m^3/s)	2,95	33,2	1,89

La dégradation spécifique en T/Km2/an, selon le rapport national marocain (Comité National Mab, 1979):

-	Neckor	3.500
-	Loukkos	1.800
-	Tleta	2.200

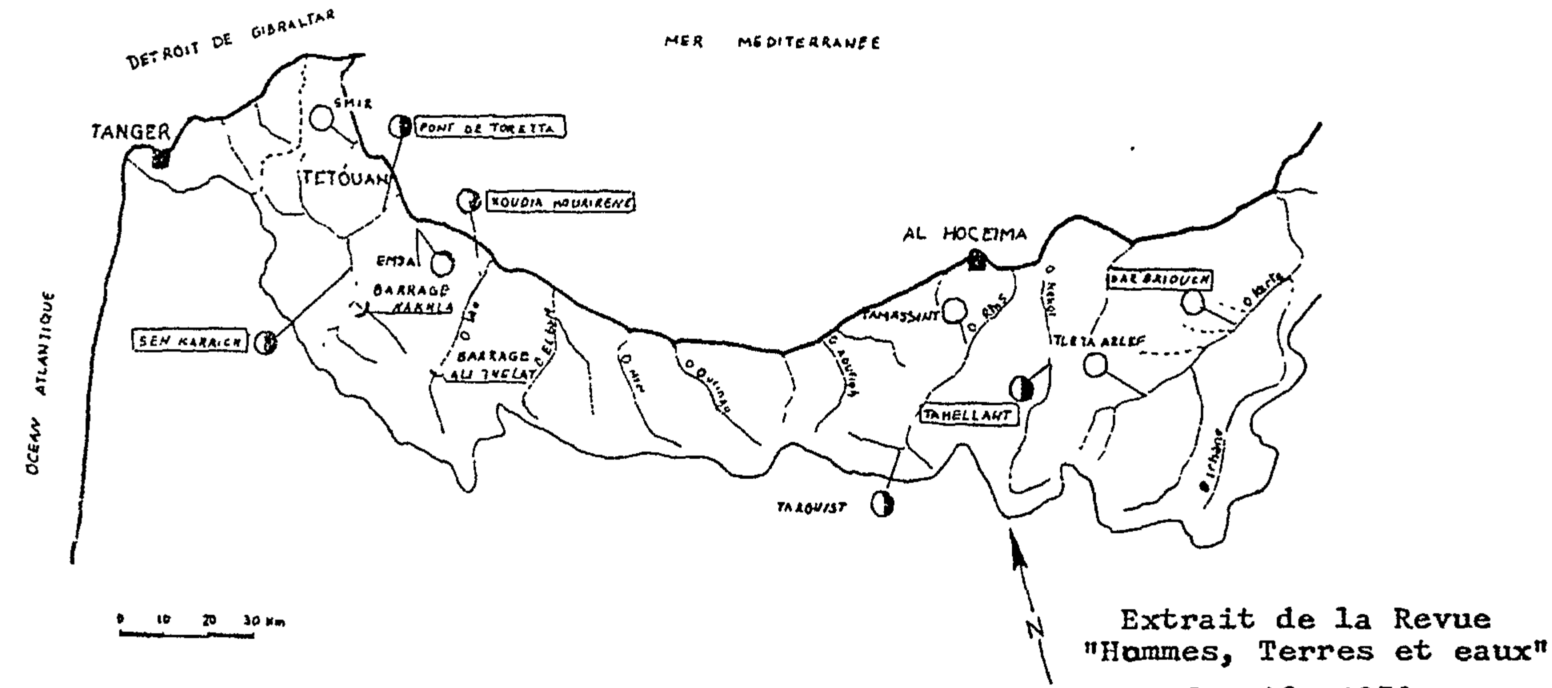
Quant à l'occupation forestière par Bassin versant, elle se présente comme suit:

-	Neckor	2%
-	Loukkos	21%
-	Tleta	2%

Mesures d'assainissement appliquées

Cadre et instruments juridiques

Il convient de signaler qu'en plus des textes réglementant la loi forestière, se sont ajoutés ceux relatifs au code des investissements agricoles (1969), qui arrête et précise les modalités concernant les dispositions afférentes à la mise en valeur des terres.



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"Hommes, Terres et eaux"
N : 30 1979

Fig.7 Bassins côtiers méditerranéens

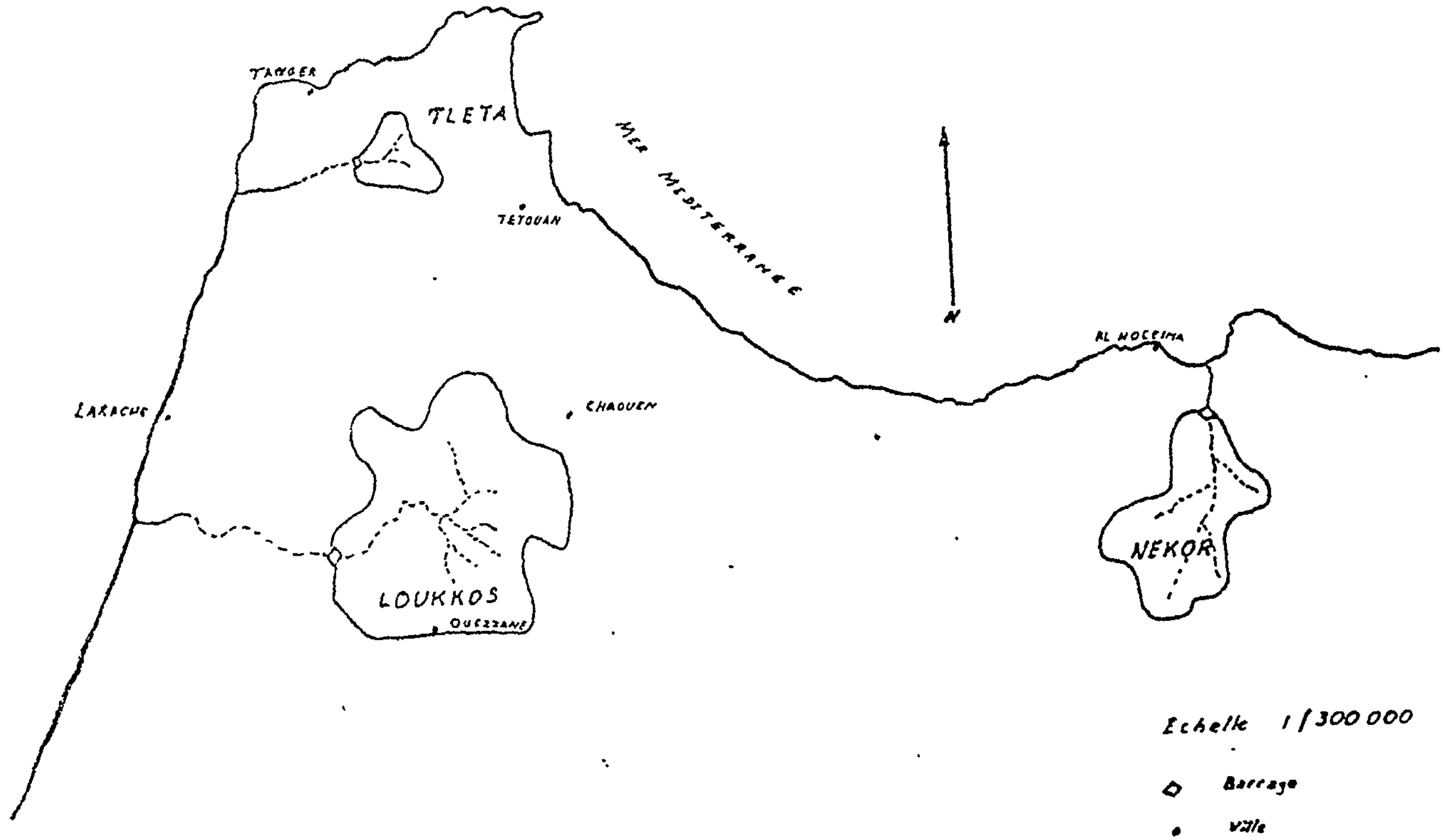

Fig.8 Localisation des projets (Pasket, FAO 1981)

Le volet portant sur la création de périmètres pastoraux ainsi que celui relatif à l'intensification de la production animale et végétale, ont été mis en exergue et les rôles du pasteur et de l'agriculteur ont été renforcés et bien définis.

Par ailleurs, pour ce qui est du bassin versant du Neckor et en raison de ces conditions physiques particulières, il a été érigé récemment en P.I.N. (Périmètre d'Intérêt National) pour mieux favoriser la mise en place d'une infrastructure anti-érosive.

4.2. Aperçu sur les actions entreprises

A cet égard, il convient de rappeler, au préalable, que des interventions multiples ont été menées dans le cadre du service de la DRS (Défense et Restauration des Sols), créé à cet effet depuis 1950.

De la même manière et toujours dans un souci d'amélioration du niveau de vie des populations montagnardes et de conservation des sols, la contribution du projet DERRO (Développement Economique et Rural du Rif Occidental) créé depuis 1963 a été satisfaisante.

D'autre part, dans le cadre du projet MOR 71/536 des études et analyses ont été menées pour quelques bassins versants du Rif, notamment: Loukkosm Neckor et Tleta.

Ce qui a abouti à l'établissement des schémas directeurs faisant ressortir les évaluations nécessaires en matière de besoins en conservation des sols, avec un planning d'interventions, principalement biologiques et mécaniques.

Interventions biologiques

Ces actions portent essentiellement sur les reboisements et le développement des cultures arboricoles et fourragères avec une utilisation rationnelle des sols en vue de réduire l'érosion.

En outre, une production supplémentaire en faveur du cheptel est fournie aux populations (Loukkos). De même que ces reboisements répondent en partie aux besoins énergétiques et de consommation des riverains, ceux-ci procèdent notamment à l'élagage gratuit du peuplement sous le contrôle technique du service forestier. Ce qui leur permet de bénéficier de quantités appréciables de bois ainsi recueillies.

Les principaux types d'interventions biologiques entreprises se résument comme suit:

Aménagements agricoles

- Dans les zones d'arboriculture ou de cultures annuelles en sec, diverses techniques sont employées en fonction de la topographie et du substrat en dépit des difficultés inhérentes au morcellement intense de la propriété.

- Installations de cordons végétaux (haies vives) en limites de parcelles (Loukkos).

- Murettes en pierres sèches: quoique d'un coût élevé, mais avec l'avantage d'avoir un effet psychologique sur la population (Loukkos).

- Impluviums sur éléments de banquettes ou de gradins réalisés par les agriculteurs eux-mêmes à la suite des distributions gratuites des plants fruitiers (olivier, amandier, noyer, vigne, figuier) au titre de subventions en nature.

Aménagements pastoraux (Loukkos)

- Installations de prairies permanentes.
- Création de bandes fourragères.
- Initiation à l'introduction de cultures fourragères en remplacement de la jachère, en rotation avec les céréales.
- Amélioration des parcours par introduction d'arbres et arbustes fourragers.

Aménagements forestiers

Il s'agit principalement de reboisement à caractère de protection conçu avec une technique appropriée de préparation du sol.

En outre, il est important de signaler qu'une attention particulière se porte à chaque fois sur le choix des espèces à introduire. Des prospections écologiques et pédologiques préalables sont menées au niveau de chaque cas dans le cadre de la programmation et de la planification menées. Ainsi, à partir des espèces locales et du comportement et de l'adaptabilité des essences composant les reboisements déjà existants, un choix concluant s'opère.

Interventions mécaniques

La nécessité impérieuse de trapper le maximum de sédiments pour une meilleure protection de l'infrastructure aval, confère à cette action une place de choix quant à l'installation et à l'édification des seuils nécessaires étant donné leur efficacité à court terme.

Il s'agit bien en effet de:

- contrôler le transport des matériaux érodés et charriés;
- réduire l'érosion des berges.

C'est ainsi que plusieurs modèles de petits ouvrages de correction mécanique (avec reverdissement) ont été implantés:

- seuils en maçonnerie de pierres sèches;
- seuils en maçonnerie de pierres sèches avec grillage gabion galvanisé; Ces derniers sont de largeurs variables selon les sites et de hauteur ne dépassant pas 4 à 5 mètres au-dessus des fondations.

- seuils en grillage métalliques filtrant. Ceux-ci présentent une hauteur de l'ordre de 1 m à 1,50 m avec une largeur qui oscille entre 1 à 5 m.

L'existence de la pierre tant en quantité qu'en qualité conditionne la répartition et la nature du seuil à bâtir.

Quant à l'exécution de ces ouvrages, elle s'est beaucoup renforcée et les seuils installés résistent parfaitement aux diverses sollicitations dont ils font l'objet.

D'autre part, les estimations effectuées quant à la capacité de rétention de ces seuils donne un coût du mètre cube de sédiments trappés de l'ordre de 15 à 20 Dhs (Pasket, 1981).

Les seuils construits, atterris en majorité, ont donc joué pleinement leur rôle anti-érosif. Des dispositions ont été prises à chaque fois en vue d'éviter tout creusement ou affouillement à leur base, par suite du déchargement des eaux de leurs éléments solides au niveau de la hauteur du seuil et de la reprise de leur pouvoir érosif à l'aval.

De même qu'une attention particulière est toujours accordée au choix du site, à la conception de l'ouvrage et à son dimensionnement, des mesures et levées appropriées sont effectuées par sous-bassin lors des travaux de planification et programmation.

Ajoutons enfin que les seuils, une fois atterris, sont directement végétalisés par l'utilisation d'espèces locales: laurier-rose, saules, peupliers, roseaux. Cette végétation est essentielle car elle constitue le "relais" indispensable en vue d'une fixation effective et durable du ravin.

En effet, l'expérience a prouvé la faible capacité des seuils à enrayer un phénomène d'érosion. Quand il s'agit d'interventions ponctuelles, souvent l'installation en elle-même de ces seuils s'avère négative, du fait du décapage qu'elle crée à l'aval.

Ainsi est-il impératif de procéder toujours à l'association conjointe des actions mécaniques et biologiques.

Travaux forestiers et résultat du reboisement

Le reboisement tant au niveau des zones névralgiques exigeant une couverture végétale continue (reboisement de protection) qu'à celui de la mise en valeur de mattorals ou de chênaies dégradées dans un but de protection, demeure une action fondamentale.

D'ailleurs la Direction des Eaux et Forêts s'était engagée bien auparavant, dans une stratégie globale de reboisements avec ses moyens d'investissements propres et avec ceux octroyés au DERRO ou à la promotion nationale (P.N.).

Le choix des terrains susceptibles de recevoir les interventions forestières s'opère selon les recommandations du schéma-directeur mais aussi en fonction des prospections et reconnaissances entreprises lors des enquêtes locales.

Ce qui permet de pallier aux diverses contraintes souvent rencontrées tant sur le plan physique ou social, et d'inscrire par ailleurs toute action de reboisement dans le cadre d'un plan global intégré.

Pour ce qui est des techniques, elles sont déterminées à l'évidence par le climat, la topographie, l'exposition et le substrat.

Quant aux essences, elles tiennent compte, comme il a été déjà soulevé, des faits suivants:

- adaptation et comportement des essences utilisées dans les travaux déjà existants;
- efficacité anti-érosive;
- utilité et production.

D'autre part, le recours concluant aux techniques d'ensemencement direct de graines (cèdre notamment) mérite d'être souligné au passage.

En outre, l'examen de la situation des reboisements existants, soulève les remarques suivantes:

- Dans les conditions particulières du Neckor, principalement au niveau du bioclimat de l'oléolentisque à thuya, l'hypothèse d'une plantation à double objectif, protection et production, est à exclure. D'ailleurs, cette perspective de production n'est pas toujours assurée même dans les zones à bioclimats favorables, étant donné l'état encore jeune des peuplements (Debazac, 1976).

- L'efficacité anti-érosive des reboisements qui se manifeste surtout à long terme est évidente dans la mesure où l'on assiste à une reconquête de la végétation. Reste toutefois à lui assurer une technique minutieuse et adéquate de la préparation du sol (DEFCS, 1978).

Cette efficacité est pleinement atteinte avec la complémentarité mécanique.

- Des travaux d'ingénierie de correction torrentielle ont été associés aux reboisements pour une maîtrise accrue des éléments d'érosion.

- L'expérience acquise dans la réalisation des reboisements permet de disposer à l'état actuel d'une gamme de données utiles aussi bien pour les techniques à adopter que pour le choix des essences à introduire.

Enfin, et en matière de reboisement, la zone rifaine offre généralement des potentialités considérables avec des possibilités prometteuses et sûres de production.

Ce qui confère d'ailleurs à cela un intérêt particulier est le fait que les forêts marocaines ne peuvent subvenir que partiellement aux besoins du pays en bois d'oeuvre, bois de mine, bois de service.

Par conséquent, la généralisation du reboisement à base de résineux dans les endroits favorables et propices est de nature à contribuer à combler ce déficit et à faire économiser ainsi au pays une bonne partie des devises dont il a grandement besoin.

4.3. Analyse économique du projet, tout particulièrement des activités forestières et d'assainissement

S'il est encore prématuré de pouvoir procéder à une analyse économique détaillée en raison du manque d'un certain nombre de données chiffrées et quantifiées, il est un aspect qui mérite d'être largement évoqué et dont les répercussions, sur le plan social particulièrement, ont été bénéfiques.

Il s'agit des ouvertures de pistes sur plus de 180 km pour le bassin versant du Neckor qui est ainsi entièrement désenclavé.

Ce qui a permis par ailleurs, outre une plus grande facilité dans les interventions, l'installation d'équipements sociaux: écoles, dispensaires, et une meilleure circulation des populations.

D'autre part, l'injection de crédits importants sous forme de salaires dispensés aux populations a donné création à un nombre élevé de journées de travail et a assuré ainsi, bien qu'en partie, la promotion de l'emploi.

De même, les subventions en denrées dans le cadre du PAM en tant que suppléments de salaires sous forme de blé tendre et de sucre ont été d'un apport bénéfique et appréciable.

Enfin, la contribution à la réduction des phénomènes érosifs et à la diminution du volume des matériaux solides (bien que difficilement chiffrable) est nette au vu des périmètres reboisés et stabilisés ou encore en rapport avec les importantes masses solides attrapées au niveau des seuils de sédimentation.

Quant aux observations à émettre sur le projet, il convient de distinguer d'une part:

- un schéma directeur fort ambitieux de par ses fondements et sa conception ainsi que dans ses analyses et recommandations d'ailleurs assez loin des réalités et aspirations sociales;

d'autre part:

- des moyens et possibilités d'exécution relativement modérés tant sur le plan humain que matériel.

En outre, l'information, la sensibilisation et la vulgarisation qui constituent l'élément moteur et la clef de voûte indispensables pour mener à bien toute action de mise en valeur appropriée dans un but d'une meilleure utilisation des terres, méritent d'être développées davantage.

4.4. <u>Possibilités d'application et perspectives de coopération dans le cadre du PAP</u>

La zone rifaine, par sa variabilité, l'ampleur, la complexité et la multitude des phénomènes d'érosion qui la caractérisent, constitue un vaste champ d'essais et d'application en matière de protection des sols.

C'est ainsi que plusieurs variantes d'interventions précitées ont été mises à l'épreuve par suite de leur application mais surtout de leur adaptation aux caractéristiques spécifiques à chaque région.

La généralisation de ces techniques pourrait être envisageable en raison de la similitude relative des conditions physiques et des problèmes d'érosion au niveau méditerranéen. Mais il convient de préciser que tout essai dans ce sens suppose une analyse plus ou moins approfondie, à la fois du milieu physique mais aussi du degré de l'impact éventuel du contexte social local.

Toutefois, si la possibilité de transfert de certaines techniques demeure aléatoire, le domaine de la coopération constitue une issue favorable et ouvre des perspectives pour des échanges prometteurs et de grands intérêts mutuels.

En effet, il s'agit là d'un volet très important dans la mesure où il permet d'assurer et de maintenir un contact permanent entre les techniciens des pays concernés en vue d'une meilleure approche des questions afférentes à la protection des sols et à l'environnement en général pour des interventions équilibrées et mieux conçues.

La création de groupes de travail et l'organisation ou l'échange d'expériences, de tournées d'étude, ne pourraient qu'avoir un effet largement

bénéfique quant à la compréhension et à la maîtrise des données afférentes à la conservation des eaux et des sols.

Par ailleurs, les possibilités éventuelles de la participation de certains pays au financement de projets particuliers dans d'autres seraient de nature à promouvoir encore davantage toute coopération et à en augmenter la portée et la signification.

4.5. Suggestions

Il est important de signaler qu'en matière de bassins versants, il y a lieu d'orienter toute action envisagée vers une intégration totale et effective de l'amont avec l'aval.

Ces deux composantes *formant déjà une même entité géographique* et *physique doivent le demeurer.*

Il s'agit en fait d'un seul et même bloc.

Il convient simplement d'inclure dans le coût de l'installation de l'ouvrage les frais à engager pour la restauration et la fixation de l'amont.

Ce qui serait de nature à mieux garantir les investissements ainsi consentis et partant, l'ensemble des infrastructures aval édifiées.

Cette intégration devrait par ailleurs faire "bénéficier" les populations rurales de l'amont des effets "positifs" de l'aval.

En effet, ces populations cantonnées dans des milieux souvent assez hostiles doivent en plus faire face et "subir" bien des restrictions imposées, notamment en matière de mise en défense par suite d'actions de reboisement.

Par conséquent, il est nécessaire de déborder du cadre restrictif actuel (limité aux seuls B.V, jugés prioritaires) pour s'inscrire dans celui, plus vaste, d'une politique globale et intégrée de l'aménagement, non seulement de l'intégrité des versant côtiers méditerranéens (Fig. 7), mais de l'ensemble du territoire.

Ce qui nécessite en premier lieu le parachèvement des travaux de délimitation du domaine *forestier et la mise en place d'un "remembrement" judicieux et approprié, faisant ressortir les différentes classes de terres* selon leur occupation actuelle, leur degré d'érosion, leur vocation, et devant aboutir impérativement à une redistribution et à un regroupement harmonieux de l'habitat rural en vue d'une plus grande efficacité dans les interventions.

Ceci ne pourrait être envisageable, bien entendu, que par suite d'une analyse profonde de la situation existante qui doit prendre en considération en premier lieu l'élément social qui prime avant tout autre facteur.

Enfin, la diversification et le renforcement de pôles d'attraction, l'apport d'éléments de substitution pour les mises en défense, le bois de chauffe méritent d'être développés encore davantage.

De même que les efforts de vulgarisation doivent être continus, sans relâche, et assurés à tous les stades.

D'autre part, une attention particulière doit être accordée à la recherche scientifique en vue d'un suivi technique approprié du comportement de l'érosion. Ce qui permettra de mieux définir en conséquence, à la fois, études et interventions.

Quant au niveau méditerranéen, l'élément le plus important, à notre avis, passe par la coopération, laquelle doit se développer davantage pour des échanges fructueux, d'informations, d'idées et d'expériences utiles pour les pays concernés.

5. CONCLUSIONS

La protection des sols est une opération essentielle et vitale dans la mesure où elle permet d'assurer une production agricole régulière et soutenue.

Ce qui suppose à l'évidence une connaissance parfaite des diverses occupations du sol et de sa vocation avec une maîtrise des techniques de conservation pour une meilleure adaptabilité et une exploitation rationnelle des terres.

En effet, le devenir même de l'existence de l'homme demeure en corrélation étroite avec l'état du milieu qui l'entoure. Celui-ci doit être préservé en vue d'une productivité plus intense au profit de l'être humain lui-même. Une véritable symbiose doit donc s'instaurer nécessairement entre les différentes composantes de ce complexe délicat qui réunit l'homme avec son milieu (terres, eaux, flore, faune, etc).

C'est dans ce sens que, conscients de la gravité des problèmes de l'érosion que connaît particulièrement la région rifaine, des efforts importants sont déployés à tous les niveaux pour atténuer les méfaits de ce fléau, véritable "cancer" des terres.

De même que des dispositions sont également prises en vue de sauvegarder la quantité remarquable des paysages qui caractérisent cette région et l'exceptionnelle richesse de sa côte, pour une meilleure préservation et mise en valeur des potentialités du milieu environnemental.

Enfin, il est primordial de rappeler encore avec une insistance particulière le caractère social singulièrement profond et aigu qui constitue la pierre angulaire, à la fois point de transit, mais aussi de base de tout projet d'aménagement.

6. BIBLIOGRAPHIE

Benabid, A. (1982). Etudes biogéographique et dynamique des peuplements forestiers du Rif (Maroc). Annales de la recherche forestière au Maroc, Tome 23(1983):47-129.

Benabid, A. (1982). Problèmes posés par l'aménagement sylvopastoral et la reforestation dans le Rif centro-occidental (Maroc). Annales de la recherche forestière au Maroc, Tome 23(1983):385-423.

Beture Setame (1985). Protection des richesses naturelles de la côte méditerranéenne du Maroc. Réserve biologique des Bokoyas, 91p.

Debazac, E.F. (1974). Aménagements forestiers et reforestation dans le bassin versant du Loukkos, projet MOR 71/536, document de travail Loukkos No 2, 43p.

Debazac, E.F. (1976). Analyse de la situation forestière, orientation des interventions forestières, projet MOR 71/536, document de travail Neckor No 7, 28p.

D.E.F.C.S. (1978). Guide du reboiseur au Maroc, 373p.

El Idrissi, M. (1976). L'érosion et les problèmes des reboisements dans le bassin versant du Neckor, Mémoire de 3ème cycle, 153p.

Pascon et al. (1983). Les Beni Boufrah, essai d'écologie sociale d'une vallée rifaine (Maroc), 297p.

Paskett, C. (1981). Travaux de correction des ravins. Un premier bilan, projet MOR 78.015, 28p.

Revue "Hommes, terres et eaux" (1979). Numéro spécial sur l'aménagement intégré des bassins versants dans le bassin méditerranéen, No 30.

Schéma d'aménagement du bassin versant du Neckor, 1977 - Projet MOR 71/536, document de synthèse, 44p.

Section des inventaires et aménagements (Service forestier d'Al Hoceima), aménagements des cédraies, subéraies et maquis du cercle de Targuist: (1980) Etude de base, 245p; (1981) Projet d'aménagement commune rurale de Beni Bounsar, 102p; (1985) Projet d'aménagement commune rurale d'Abdelghaya-Souahel, 203p.

Stefanesco et al. (1976). Les ressources pastorales et d'aménagement des terrains de parcours, projet MOR 71/536,

Thirion, J. (1976). Etude des ressources en terres, description des unités physiographiques et occupation actuelle des terres, projet MOR 71/536, document de travail Neckor No 4, 50p.

Thirion, J. (1975). Etude des ressources enterres, description des unités physiographiques et occupation actuelle des terres, projet MOR 71/536, document de travail Loukkos No.5, 30p.

Viertmann, M. (1977). Programmation et réalisation des travaux, Volume I, projet MOR 71/536, 139p.

Zitan, A. (1985). Développement de la production fourragère étude des parcours forestiers, projet TCP/MOR 4402, 111p.

PROTECTION OF AGRICULTURAL LAND FROM NON-AGRICULTURAL USES IN THE ADRIATIC COASTAL ZONE

by

M. JANJIC
City Planning Institute
Beograd, Yugoslavia

1. GENERAL INFORMATION ON THE PROBLEM

1.1 Introduction to the problem as a world-wide phenomenon

"Land because of its unique nature and the crucial role it plays in human settlements, cannot be treated as an ordinary asset, controlled by individuals and subject to the pressures and inefficiencies of the market. Private land ownership is also a principal instrument of accumulation and concentration of wealth and therefore contributes to social injustice; if unchecked, it may become a major obstacle in the planning and implementation of development schemes. Social justice, urban renewal and development, the provision of decent dwellings and health conditions for the public can only be achieved if land is used in the interests of society as a whole"(1).

"Land is the essence of life. Without it life as we know it would never have started and could not have continued throughout the ages. As the source of all food supply, land is a common concern over the entire globe, regardless of political or social circumstances. In another sense, land is location or space and is equally essential to our continuing existence. All human activities need land for housing, industry, education, health and for the transportation systems connecting all those activities and the communities that comprise them. Land is both the source of living and the space on which to live. The conflicts between these two functions emphasise their interdependence and complementary requirements"(2).

One of the essential characteristics of the contemporary world is urbanisation which, as a process, is substantially linked to land. Social, economic and migratory processes are manifested on the land and, through various forms of land "spending", settlements and towns are formed. Towns have been both praised as symbols of the progress and modernisation of human civilisation and criticised and frequently blamed for various shortcomings and contradictions. Socio-economic development and urbanisation have, in particular, led to several conflicting situations over the spatial use of land. Among them three are the most significant.

Firstly, land should be used for agricultural purposes - for food production or as living space for locating various non-agricultural functions such as housing, industry, transportation, recreation and commercial and public activities. Secondly, a conflict has arisen between land as a resource

(1) "Report on Habitat: United Nations Conference on Human Settlements", UN Resolution 32/162.

(2) Nathaniel Lichfield: "Settlement Planning and Development: A Strategy for Land Policy Issues, "Centre for Human Settlements", 1980.

and as a commodity. In terms of production and the working theory of value[3], land is a natural resource and is therefore priceless. But it is the sole natural resource that is a basis for others - minerals, water, fauna and flora, light, air and sunshine. Since land is a limited natural resource, it must be treated as a commodity which has its price and is subject to supply and demand on the market. The third conflict is between private ownership of land developed under free market conditions and ownership subject to government intervention and control.

These conflicts have different repercussions in most Mediterranean countries which have in the past developed under different historical, social and economic conditions. At the same time, the process of urbanisation has varied in intensity and form. Unlike today's developed countries in which the transformation processes in space took much longer, in the developing countries these processes have been much faster, taking place well ahead of industrial development. The reasons for this may be summarised in the following way.

Firstly, due to a delayed pre-industrial urban development there has been a high spontaneous concentration of the population in towns which cannot absorb such a large number of people at once.

Secondly, there has been a rapid population growth ranging from 2-3% and above while the workforce also has increased at a rate of over 2%.

Thirdly, the transformation of agriculture and an adequate development of small and medium-sized towns has lagged behind. A comparison with a number of developed countries reveals that in each case the percentage of people living in cities is much lower than the percentage of the workforce employed in industry. For example, at the end of the 19th century, in France and Portugal 10.6 and 8.0% of the population respectively, lived in towns with 20,000 and more inhabitants while 29 or 19% of the working force was employed in manufacturing. In the developing countries the situation is quite the opposite. So for instance in the fifties in Algeria 18.2% of the population lived in towns of 20,000 inhabitants and over and 5.6% of the economically active male population was employed in manufacturing. The corresponding figures for Morocco are 26.9% and 6.2%, for Tunisia 17.5% and 6.8%, for Egypt 16.0% and 9.6%, and for Turkey 18.2% and 8.7%[4].

Migrants from the countryside still believe that urban life can hardly be worse in comparison with the village way of life. There are few cases of a repetition of Japan's beneficial spiral at the turn of the century when the farmer, free of feudal dues and doubling his productivity paid the land tax which helped to finance industry, grew the food that fed the cities and then purchased back from them the bicycles and sewing machines of the new industrial era. This process still continues in Japan through a combination of sophisticated technology and, as a complement, small-scale industry which is also developing in smaller towns and settlements. This has certain positive implications for the process and form of urbanisation and land use as living space and for food production.

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(3) Adam Smith: "The wealth of Nations".

(4) World Bank: "Urbanization" - Sector working paper, June 1972.

The terms most frequently used to define measures and instruments for protecting agricultural land from non-agricultural use are: land policy, land use policy, land reform, control of land use policy, "urban" land policy etc. In theory and practice one most often encounters the following terms: land policy, land use policy, urban land policy, public land management, land title : registration, land laws and courts, property taxation, property evaluation, public goods, public utilities, public transport, government property management. In addition, concepts used in practice include: central government fiscal and monetary policies, housing policies, regional development policies, urban planning, spatial and physical planning.

Proceeding from the experiences of the Mediterranean countries and for the purpose of this study we feel that the most adequate term would be "land use policy" as it covers the functions of central, regional and local government in several directions. Central government is responsible for passing laws which affect real property and the taxation of private land which regulate the ways and means of using public land(5). The government is also responsible for setting up physical, regional and urban planning systems for controlling land use and development. Local government is responsible for coordinating land use and resolving the conflicts between agricultural land building (and built-up land in urban areas) and it delegates to various bodies the right to develop, control and use urban land. Forms of acquisition, compensation, evaluation and rating, land disposal arrangements and land development accounting are also regulated by the central or regional governments.

According to habitat recommendations, land use policy should be viewed as a part of development policy. The reason for this can be found in the difficulties of identifying where land policy finishes and development policy begins. Dwelling construction on new housing estates, purchase or expropriation of land for urban renewal or for the promotion of industrial facilities can be considered as land use policy. Some doubt may arise, in the case of, for example, a tax on vehicles in congested areas as an aid in minimising traffic problems. There may also be some doubt when it comes to making a clear distinction between urban and development plans. That is, policies relating to the use of agricultural land such as reforms in tenure, cooperative production, marketing, introduction of new machines and technology would be considered relevant to the implementation of rural development plans. However in most cases there are hardly ever any such measures in the physical plans of communes and they are never found in the master plans of cities.

In this connection, the protection of agricultural land from non-agricultural uses should comprise two groups of inter-connected activities and measures designed to regulate relations between agricultural and building land. Those are in the first place: land resource management, control of land use changes, recapturing land rent, public ownership, ownership patterns, preservation and improvement of land and information required in data banks and other means of disseminating or storing information needed for land policy.

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(5) In Yugoslavia, land is socially owned. The Republican Government is responsible for legislative activities and the local for regulative activities. The local municipalities have the right and obligation to manage the socially-owned land on their territory and to protect agricultural land under the relevant laws.

1.2 Specific features of the problem in the Mediterranean coastal zones

In the not too distant past, most of the Mediterranean countries belonged to the category of less developed or under-developed. In addition, regional differences were very pronounced. In the European part of the Mediterranean, the coastal zone was highly under-developed with traditional forms of production, life and work dominating, and with poor communication with the hinterland. The under-developed southern regions of Spain, France, Italy and Yugoslavia provide very good illustrations of this pattern. In the coastal zones an under-developed network of small settlements predominated with the population mainly engaging in fishing, olive and vine growing and traditional livestock breeding and navigation. Economic migration was a regular occurrence.

However, the African coastal belt was more developed as a result of colonialism and the need to exploit its natural resources. In any event, even such a developed narrow coastal belt could not significantly change the overall picture of economic under-development. A more developed north and an under-developed south is characteristic of these countries too.

Following the Second World War, significant economic development measures were undertaken in the European part of the Mediterranean. The collapse of colonialism and the acquisition of independence made it possible for these African countries to make a significant breakthrough in their economic development. The development of industry, tourism, communications, fisheries, ship-building, etc. gave a strong impetus to transformation processes in the Mediterranean zone.

The process of economic migration slowed down and even halted but migratory processes from the villages to the towns and from the under-developed towards the developed regions which suddenly became attractive were initiated. First industry and then tourism effected a redistribution of the population and the formation of new points of attraction in space. Development processes also led to a redistribution of the value of land which was increasingly sought after for building and other non-agricultural functions. Agricultural income started rapidly to lose the battle to various forms of urban income. The high demand for land to build on increased the value of land by more than a hundred times making agricultural production totally unattractive and pointless. The exceptions are perishable fruit and vegetables which are delivered to the cities and are needed by the tourist trade. As a result of these transformation processes the traditional network of settlements was dissolved, the population started to move to the narrow coastal belt, and to concentrate round the big towns so that these were metropolised. In many parts of the Mediterranean there is evidence of urban sprawl and the formation of an urban belt. The negative effects of such trends are the loss of extremely valuable agricultural land, its degradation, an upset ecological and social balance, sea pollution and the like.

The carrying capacity or ability of the land, sea and air to accept, and process a certain quantity of pollutants is being significantly reduced. Self-regulation is virtually impossible without major social interventions which significantly increase social and ecological spending.

2. DATA ON NATURAL, HISTORICAL AND SOCIO-ECONOMIC CONDITIONS IN THE PROJECT AREA

2.1 Reasons for selecting the area

For the purpose of this study, the region of Dalmatia has been chosen as in many respects it is representative of the Mediterranean. Numerous socio-economic transformation processes have been taking place in the region since the Second World War which have had definite manifestations in space so that they have changed its morphology to a significant degree. Since similar transformation processes are in evidence in the coastal zones of other Mediterranean countries, the generalisation of findings for the Dalmatian region may be relevant to areas with similar characteristics in other countries.

The Dalmatian region covers the coastal belt together with a large number of islands. A large number of small traditional settlements have been formed over the ages along the coast and on the islands. Human experience accumulated over the centuries has developed in the population a fine sense for building those homes best suited to their needs.

The region of Dalmatia is a restless one from the demographic point of view. Up to the Second World War the population from particular parts and especially from the islands tended to go abroad, especially to overseas countries in search of employment. The imbalance between the natural and particularly the man-made resources on the one hand and the population on the other, forced people to look for work and a source of livelihood in other parts of the country, in Europe and in America.

With the development of industry, the construction of roads, public utilities and later the development of tourism and related functions, conditions were ensured for an accelerated social and economic development of this region. Though economic migrations were checked, a spatial redistribution of the population within regions carried on, while emigration regions turned into regions of immigration. The coastal areas became attractive for inhabitants of other parts of the country as well.

The region of Dalmatia can conditionally be divided into three characteristic parts or sub-regions:

- islands
- coastal zone
- hinterland

The population trends in the 1900-1981 period are shown in Table I.

The population in the coastal zone more than doubled which meant that thanks to its economic growth the narrow coastal belt was able to accept, accommodate and productively employ most of the disguised unemployment from the islands and much of that from the Dalmatian hinterland.

The concentration of the population in the narrow coastal belt together with the development of various littoral functions indicates that this region leaning towards the sea constitutes a link between the hinterland and the Mediterranean. Virtually all economic activities and particularly those depending on and closely related to the sea can be found in this region. An

illustration of the interdependence and inter-connection between the region of Dalmatia and the sea is provided by the development of shipbuilding, maritime transport, fisheries, tourism, foreign trade and generally the various forms of communication between the country's hinterland and the rest of Europe and the Mediterranean.

Table I

Population from 1900-1981

	1900	1981	Index	Difference (+) or (-)
Total	545 184	882 050	161,9	+ 336 866
Islands	73 185	47 434	0,64	- 25 751
Coastal zone	272 010	587 320	215,9	+ 315 310
Hinterland	199 989	247 291	123,6	+ 47 302

In addition to definite positive development results, as can be seen from the totally changed image of this region, there have also been some negative effects which are manifested in various ways. Urban implosion has led to the growth of small and medium-sized cities into large ones coupled with spontaneous metropolisation and urban sprawl. Planned and organised urbanisation has been intertwined with a spontaneous one in which illegal housing has involved the division of the land into plots and the transformation of agriculturally and economically valuable land into building plots. This has also led to a certain degree of ecological imbalance, especially between natural and socio-economic processes. Natural resources, land, water, air, have over the centuries formed a given morphological structure which has a certain carrying capacity which had to yield to the pressures of rapid and spontaneous urbanisation.

2.2 Borders of the area

The Dalmatian region covers an area of 11,785 km^2 or about 1,175,800 ha. It is situated in the central part of the Socialist Federal Republic of Yugoslavia and the southern part of the Socialist Republic of Croatia. It stretches about 370 km as the crow flies from the town of Zadar in the north-west as far as Dubrovnik in the south-east. The maximum width of the coastal belt is 78 km and the minimum less than 10 km. As already mentioned it consists of the islands, the coastal part and the hinterland.

The largest and most important towns - Split, Sibenik, Zadar and Dubrovnik - are located in the coastal belt. The population of these towns accounts for about 86% of the population of the coastal belt and about 56% of the total population of Dalmatia. About 80% of all activities in Dalmatia are concentrated in the coastal belt, mostly in the above-mentioned towns and their immediate surroundings. Ecological problems are most pronounced in this belt; agricultural land is most in jeopardy while valuable land in other parts is being abandoned.

2.3 Historical development

The remains of Greek and Roman settlements of architectural and historical value clearly show that this region has attracted people to live, work and settle since time immemorial. The Greeks in their day brought to these parts crafts, commerce and shipping while the Romans contributed their administrative-military organisation. The Diocletian Palace in Split is just one of the many symbols of the one-time domination of the Roman Empire. The famous Roman road Via Raguza from Trieste to Split and Dubrovnik (Raguza) went inland to link up with the Via Militaris from Ljubljana (Emona) to Sremska Mitrovica (Sirmium) and Belgrade (Singidunum).

In the Middle Ages, Venice and the Venetians dominated the region, particularly the coastal, northern part while Dubrovnik enjoyed autonomy and the economic and political influence of the Dubrovnik Republic prevailed in the south.

Agriculture was the dominant economic activity. Olive and vine-growing and the production of widely known Dalmatian wines for which the region was famous, developed on the islands and the coastal belt while livestock breeding was developed in the hinterland. Navigation, commerce and mediation in the sale of goods and services were also engaged in and provided a source of income for the population and for the payment of various contributions, for acquiring trading and transportation licences, etc.

Due to poor communications with the hinterland and even within the coastal belt itself, communities formed round individual centres which differed in terms of economic activities, customs and cultural orientation. This variety together with the mixing of Slavs with the indigenous population led to the formation of a unique Dalmatian charm which is characteristic, in particular, of the female population. A Dalmatian woman is an interesting blend of femininity, openness, integrity and restraint. These character traits combined with the beauty of the scenery, the sun and the sea give this region an image all its own.

2.4 Population and employment

The process of transforming agrarian land into land used for other purposes acquired particularly large-scale proportions in the period from 1961 to 1981. In the sixties, about 42% of the population of Dalmatia lived off agriculture while in 1981 this percentage dropped to a mere 6.6%.

Table II

Agricultural and non-agricultural population

	1961	Structure	1981	Structure	Index
Total	757 288	100,0	882 050	100,0	116,4
Agricultural	316 954	42,0	58 256	6,6	18,3
Non-agricultural	440 334	58,0	823 794	93,4	187,0

Sources: Population census 1961 and 1981

In this twenty-year period, some 258 thousand people switched over from agriculture to non-agricultural activities or 13,000 people on average each year. By far the largest share (about 90%) are concentrated primarily in the territory of the municipality of Split, followed by the municipalities of Zadar, Sibenik and Dubrovnik. In the case of the municipality of Split, the agricultural population has virtually disappeared, as in 1981 only 1% were registered as such. In the territories of Zadar and Sibenik there is an average of about 5% and in the territory of the Municipality of Dubrovnik about 11% of agricultural population as in the remainder of the coastal part of Dalmatia. Most of the non-agricultural population is employed in the social sector of the economy, primarily in industry, trade, catering and tourism, in transport and the building industry. Total employment in the social sector of the economy in 1981 amounted to about 252,000 or about 30% of the total non-agricultural population. If we add to this the by no means insignificant number of people working in the private sector of the economy, the employment rate goes up to 35-38 percent.

Table III

Employment in the Social Sector in 1971 and 1981

	1971	Structure	1981	Structure	Index
Total	168 122	100,0	252 211	100,0	150,0
Islands	9 330	5,7	14 292	5,7	153,2
Coastal zone	132 788	78,9	197 330	78,2	148,6
Hinterland	26 004	15,4	40 589	16,1	156,0

Source: Statistical yearbook of SR Croatia

Though the employment rate in the social sector on the islands and in the hinterland has been increased to some extent over the past few years, by far the largest number of work places are concentrated in the coastal part of Dalmatia. The population-employment ratio provides the best illustration.

Table IV

Population and employment in 1981

	Population	Structure	Employment	Structure	Difference (+) or (-)
Total	882 050	100,0	252 211	100,0	
Islands	47 434	5,3	14 292	5,7	+ 0,4
Coastal zone	587 320	66,5	197 330	78,2	+11,7
Hinterland	247 291	28,2	40 589	16,1	-12,1

The highest concentration of the population and naturally of employment is on the coast. However the employment share in relation to the population share is higher by 11.7 points on the coast and lower by 12.1 in the hinterland. This is an indication of daily migrations from the hinterland of people working on the coast. The employment share on the islands matches the population share as an insignificant percentage of the islands' population travels to work daily in the coastal zone.

Industrialisation and the development of the social division of labour have had a multifold effect on the redistribution of the population and its concentration in the coastal belt. A more even distribution of the population in a large number of small urban and rural settlements would not have allowed the development of necessary services which require a minimum population concentration or threshold.

The availability of external economies, skilled and unskilled labour, complementary economic activities, schools and health care institutions, cultural establishments, etc. is a precondition of development. At the same time for public transport and cultural establishments such as the university, theatres, clinical centres to be formed, a certain concentration of the population is required.

On the other hand, industrialisation has attracted the disguised unemployment from the rural areas which has enabled labour productivity in agriculture to be increased. Under conditions of a traditional economy, agriculture barely managed to provide food for the villagers. Today, having been relieved of surplus labour, agriculture produces food surpluses for supplying the towns. As a result, in the initial stages of development, agriculture too derived considerable benefit from industrial development which, in addition to absorbing the disguised rural unemployment, provided it with farming machinery, equipment, new technologies, pesticides and herbicides, new seed varieties (hybrids), etc.

These transformation processes significantly strengthened the non-agricultural sectors of the economy and particularly the secondary and tertiary sectors as can be seen from the following Table V.

Table V

Employment in 1971 and 1981

	1971	Structure	1981	Structure	Index 1981/1971
Total	168 122	100,0	252 211	100,0	150,0
I Primary	8 818	4,4	5 178	2,4	58,7
II Secondary	64 114	38,1	101 254	40,2	158,0
III Tertiary	64 981	38,6	98 726	39,1	152,0
IV Others	31 815	18,9	46 051	18,3	144,7

The extent of the transformation process of agriculture into non-agricultural activities appears to have been far greater than could have been expected. For, not only did the share of agricultural population in the total population from 1961 to 1981 drop from 42% to 6.6%, but there are even indications of employment declining in the social sector of agriculture as well. Obviously the causes of these trends are far deeper and should probably be sought in the status of agriculture, in the price parity of agricultural products, in the system of taxation and above all in the inadequate perception of relations between agricultural and non-agricultural income which is manifested in various ways in the coastal region.

The effect of the above-mentioned factors can be assessed on the basis of trends in the non-agricultural and urban population. For, one of the problems of the Mediterranean countries is that urbanisation processes develop at a much faster rate than the process of overall economic development and in particular the industrialisation process which can partly be seen from the Table VI on the following page.

The data contained in Table VI point to a number of interesting conclusions. The non-agricultural population is growing about 6 times as fast as the total population. The increase in the non-agricultural population is virtually matched by the increase of the urban population. About two-thirds of the total population and an incomparably higher percentage of the urban population lives on the coast. Thus in 1981, for instance, 66.5% of the total population and about 86.3% of the urban population lived on the coast. This shows that the process of geographic concentration and urbanisation has swept the coast in both absolute and relative terms. Furthermore, as the urban population accounts for 66.3% of the total, on the basis of this indicator, the coast can already compare with the developed countries in which the share of the urban population in the total ranges between 70 and 85%.

2.5 Development of buildings and roads

For an evaluation of the relationship between agricultural and non-agricultural functions, it is particularly important to examine the urban activities which can be described as major land users. It has been underlined above that land is a precondition of any human activity whether it is used as a means of production in agriculture or as a locational commodity for the development of various urban functions and communication systems, primarily roads and corridors for production and transmission of various types of energy.

From the standpoint of the use or "consumption" of agricultural land for the needs of urbanisation and industrialisation, numerous urban activities can be divided into large and intensive consumers. The leading large consumers of land are housing, industry, traffic and recreation which account for up to 85% of the total urban land reserved for construction. Therefore, if a satisfactory degree of rationality in the use of urban land for the above-mentioned activities is achieved, the other urban functions can quite easily be adjusted to the criteria relevant to large consumers.

The rapid growth of the urban population in the coastal part of Dalmatia has significantly contributed to the transformation of agricultural land into urban build-up land. The rate of growth of the urban population in Dalmatia was incomparably higher than in other parts of the country. It is estimated that the urbanisation rate in Yugoslavia in 1981 amounted to about 55%. Immediately after the war the rate was about 17%. Even if it was slightly above this average for Dalmatia, it is quite certain that in thirty years time this percentage has increased about four times over.

Table VI

Total agricultural and urban population

	1981	Structure	1981	Structure	Index 1981/1961
	1	2	3	4	5
(a) Total population					
Total	830 074	100,0	882 050	100,0	106,3
Islands	50 779	6,2	47 434	5,4	93,4
Coastal zone	514 523	61,9	587 325	66,6	114,1
Hinterland	264 772	31,9	247 291	28,0	93,4
(b) Agricultural population	1971		1981		
Total	222 276	100,0	58 256	100,0	26,2
Islands	15 402	6,9	5 454	9,4	35,4
Coastal zone	83 195	37,4	24 912	42,8	29,9
Hinterland	123 679	55,7	27 890	47,8	22,6
(c) Non-agricultural population	1971		1981		
Total	607 798	100,0	823 794	100,0	135,5
Islands	35 377	5,8	41 906	5,1	118,4
Coastal zone	434 328	71,5	562 473	68,3	129,5
Hinterland	138 093	22,7	219 415	26,6	158,9
(d) Urban population	1971		1981		
Total	338 402	100,0	415 573	100,0	133,4
Islands	17 689	5,3	21 026	3,8	118,8
Coastal zone	292 012	86,3	389 524	86,3	133,4
Hinterland	28 701	8,4	41 023	9,9	142,9
(e) Share of urban in total population	1971	Relations	1981	Relations	
Total	40,8	100	51,2	100	125,5
Islands	34,8	85	44,3	86	127,3
Coastal zone	56,7	138	66,3	130	117,8
Hinterland	10,8	26	17,0	33	157,4

This increase in the rate of urbanisation has been accompanied by a very high rate of housing and weekend homes' construction as can be seen from Table VII.

Table VII

Housing fund and weekend homes

	1971		1981	
	Dwellings	Weekend homes	Dwellings	Weekend homes
Total	196 903	10 098	22 110	30 017
Islands	15 137	2 642	17 778	5 816
Coastal zone	127 281	6 902	165 786	20 968
Hinterland	54 485	554	60 564	3 233
	Structure			
Total	100,0	100,0	100,0	100,0
Islands	27,0	26,6	7,0	19,3
Coastal zone	65,0	68,0	68,0	70,0
Hinterland	28,0	5,4	25,0	10,7

The increase of housing and weekend homes' construction on the coast has led to urban concentration, surburbanisation and metropolisation. The standard of about 100 m^2 of land per inhabitant obtained as a result of empirical research shows that 242,110 dwellings have consumed at least 4,500 ha of land. The traditional system of building housing units on small plots and very close together in order among other things, to save agricultural land, because of the high costs of infrastructure, has been replaced with the construction of high-rise housing primarily in towns. Though it is generally believed that this is a more rational way of using land, additional areas nevertheless had to be reserved for the construction of roads, parking spaces, green surfaces and other auxiliary facilities.

Applying the standard of 75 inhabitants per hectare, a figure of about 4,500 ha is again obtained. Most of this land has been exempt from agriculture for the needs of housing construction in the last 20-30 years. If we add to this the weekend homes built in the last 20 years or so and which have occupied at least another 1,000 ha we obtain the figure of 5,500 ha for housing alone.

Furthermore, in Dalmatia and particularly on the coast, illegal construction of housing and weekend homes is very widespread. One of the aspects of this unauthorised building is that it is highly disorganised. Land is not plotted out in accordance with the needs of planned and organised construction of roads, infrastructure and other requirements but to suit the land owners' interest of obtaining the maximum price and making the highest profit. It is estimated that on the territory of Split Municipality alone, 130 ha of land has been occupied for illegal construction. The surroundings

of Trogir, Zadar, Sibenik, Dubrovnik and other smaller localities are even more attractive for such construction so that it is estimated that about 800 ha of agricultural land has been "spent" for this purpose. For an objective picture of land occupancy by housing construction concrete surveillance and measurements are required.

The cited standards have been borrowed from countries in which construction plans are strictly respected and agricultural land fully protected. As the urbanisation rate in Dalmatia, as in other parts of Yugoslavia, has been both sponteneous and explosive, far greater areas of agricultural land can be assumed to have been occupied by housing construction.

The other major "consumer" of land is traffic. The construction of roads and parking spaces has consumed considerable areas.

Table VIII

Roads in kilometres

	1971	Structure	1981	Structure	Index
Total	5 359	100,0	5 762	100,0	107,4
Islands	565	10,5	595	10,3	105,3
Coastal zone	2 687	50,1	2 752	48,0	102,4
Hinterland	2 107	39,4	2 415	41,7	114,6

In terms of area in 1981, about 7,642 ha were occupied for the construction of roads outside towns and settlements. On the islands the figure is 1,070 ha, on the coastal belt about 3,200 ha, and in the hinterland about 2,230 ha.

The rapid increase of the motorisation level which in Dalmatia exceeds the urbanisation rate also occupies large areas of land, in motion and at rest (parking).

Table IX

Number of cars

	1971	Structure	1981	Structure	Index
Total	45 268	100,0	150 616	100,0	344,3
Islands	1 650	8,2	9 319	6,3	564,8
Coastal zone	36 947	81,6	116 182	77,1	314,4
Hinterland	6 671	10,2	25 115	16,6	376,5

If we take 18 m^2 as the minimum area required to park a vehicle, in 1971 about 170 ha had to be reserved for that purpose and in 1981 about 250-300 ha.

The third major land user is industry. An estimate of land occupancy for the needs of the construction of industrial facilities can partly be obtained from the following data.

Table X

Number of enterprises and employment in 1982

	Number of enterprises	Structure	Average number of employed	Structure
Total	352	100,0	73 357	100,0
Islands	30	8,5	4 240	6,0
Coastal zone	250	71,0	54 922	74,7
Hinterland	72	20,5	14 195	19,2

The coefficients of land occupancy are divided into three categories: small-scale industry, medium-sized enterprises depending on the branch of industry and large heavy industry enterprises. A reasonable coefficient for the latter category is about 300 m^2 of land per employed worker (covered and uncovered areas). Along the coast, there are small and medium-sized enterprises - cement works, shipyards, plastics, etc., which occupy large areas in the open space. In addition, Split and Sibenik have industries which are major sources of environment pollution for reasons of which they require special locations. Also, land earmarked for the needs of industry is not being used very rationally so that it is estimated that about 3,500 to 4,000 ha have been engaged for this purpose.

2.6 State of the environment and land

For the state of the environment to be analysed and diagnosed a register of all the natural and man-made systems and their components and elements is required. An element of the system is the basic unit-plot on which all socio-economic processes evolve. That element is the precondition, factor and cause of emergence, duration and disappearance so that on and around it all the positive-creation, and negative-destruction, consequences occur.

The principal land categories are: farming land, woods, building land and the rest (marshes, rocks) which requires additional investment to be improved and used for farming, afforestation or for building. Available data on land is extremely unreliable. The reasons for this are many but two may be singled out as of most importance. First and foremost, cadastres are not updated regularly as people do not realise how essential this is for a sound and rational policy of physical and urban development and town planning. Secondly, frequent administrative changes in terms of the formation and linkage of communes, districts and regions have caused further confusion in disordered land records.

In spite of these shortcomings, efforts have been made to carry out, on the basis of limited data, an analysis of the state and tendencies in land use.

The region of Dalmatia has a total area of 1,175,000 ha. In view of the steady population growth, the land population ratio is steadily deteriorating. Thus in 1961 for instance there was 0,64 inhabitant per hectare whereas in 1981 it went up to 0,75 inhabitant as can be seen from the following table.

Table XI

Population and land

	1961	1971	1981	Index 1981/1961
Total area in ha	1 175 800	1 175 800	1 175 800	
Agricultural land	765 437	719 602	708 504	0,92
Arable land	189 597	181 415	882 050	4,65
Total population	757 288	830 074	882 050	116
Urban population	230 000	238 402	451 573	196
Land per capita				
Total	1,55	1,41	1,33	0,85
Agricultural land	1,01	0,86	0,80	0,79
Arable land	0,25	0,22	0,20	0,80
Population per one ha				
Total	0,64	0,70	0,75	117
Agricultural land	0,98	1,15	1,24	126
Arable land	3,99	4,56	5,01	126

Though the data on land are not quite reliable there is an obvious regularity in the manifested tendencies, namely, the urban population has quadrupled in a short period of time which has resulted in the loss of agricultural land, particularly in arable areas.

As can be seen from data in Table XI, the relationship between the land and the population has been deteriorating steadily in the past 20 years. Land is a non-renewable resource and once it is extracted for building purposes it is usually permanently lost to agriculture. The population concentration in the coastal belt has resulted in the loss of a considerable portion of agricultural and arable land. The ecological balance, established over the centuries between the population and natural resources has been seriously upset. The balance has been upset not because it is impossible to accommodate in the region of Dalmatia primarily in the coastal area, about half a million or more urban inhabitants, but because of the way in which the urban population is being accommodated and the way in which towns and settlements are being organised. Just a quick glance at the form and matrix of old settlements and towns is sufficient to see that a maximum degree of rationality in construction had been ensured. Numerous objective reasons,

particularly administrative, military, defence and the like may have required such an approach. Be that as it may, the effects regarding the rational use of land were extremely positive. Naturally, the form and matrix of traditional towns is too restrained for present-day economic and technological trends. It yielded to the pressure of new, contemporary development trends so that where cannon failed in the Middle Ages and at the beginning of the industrial revolution, money, capital, technology, development - in brief, incrementalism has succeeded. There is no doubt that socio-economic development is a necessity in the contemporary world.

The inhabitants of the developing countries, like those of the industrialised countries, want a higher standard of living and welfare. The concepts of welfare and standard of living, dominant in both the east and the west, are based on quantitative indicators and the criteria of profit or income. Would it not be possible for the Mediterranean countries, in view of their traditions and age-old experience in the construction of towns, the development of agriculture and the like, to ennoble these concepts and replace them with the concept of the quality of life which comprises social and ecological as well as economic criteria? Only on the basis of such an approach can the criteria be sought out for the proper balance between the population and man-made resources.

Table XII

Agricultural and arable land in hectares

	1961	1971	1981	(+) or (-)	Index 1981/1961
	(a) Agricultural land				
Total (22 municipalities)	765.437	719.602	708.504	- 56.933	0,92
1. Split	63.43	54.695	55.293	- 8.138	0,87
2. Zadar	75.575	64.166	70.524*	- 5.051	0,93
3. Sibenik	85.478	79.365	79.144	- 6.334	0,92
4. Dubrovnik	51.369	43.647	42.386	- 9.583	0,81
Total					
(4 municipalities)	276.453	241.347	247.347	- 29.106	0,89
(18 municipalities)	488.984	477.729	461.157	- 27.827	0,94
	(b) Arable land				
Total (22 municipalities)	189.597	181.915	175.923	- 13.674	0,92
1. Split	12.999	11.523	11.564	- 1.435	0,88
2. Zadar	21.389	19.614	20.045*	- 1.344	0,93
3. Sibenik	19.925	18.530	18.603	- 1.322	0,93
4. Dubrovnik	12.250	10.193	9.465	- 2.785	0,77
Total					
(4 municipalities)	66.563	59.860	59.677	- 6.886	0,89
(18 municipalities)	123.034	122.055	116.246	- 6.788	0,94

The decline of agricultural land and arable areas has had an extremely adverse effect on those regions with intensified urbanisation and geographical concentrations of the population.

As a result of urbanisation in all its forms, in the past thirty years the area of agricultural land has been reduced by about 57,000 ha, or about 2,700 ha annually on average. In the territory of 4 communes alone in which the urbanisation process has been most intensive, about 30,000 ha or about 1,450 ha annually have on average been taken from agriculture.

According to rational town planning parameters and land utilisation coefficients, a town of about one million inhabitants with all the accompanying communications, economic, non-economic, housing and other facilities could be accommodated in an area of 10,000 ha. In practical terms this means that the entire population of Dalmatia together with a 20% increment could be accommodated in such an area.

Aside from the loss of agricultural land as a whole, there has been a reduction of arable land including ploughland, vegetable gardens, vineyards and orchards. The quality of the crops produced is well known. The comparative advantages of Dalmatian vineyards and olive groves, and various Mediterranean fruits and vegetables are generally recognised.

Thanks to the rapid development of tourism along the coast and on the islands, this produce can be marketed on the spot thus avoiding export marketing and transportation costs, while the tourists have the advantage of daily supplies of fresh fruit and vegetables. In this connection the question that arises is whether it was really necessary to lose 13,674 ha of arable land or 683 ha on average annually. In the four above-mentioned municipalities, 344 ha of arable land disappeared on average every year. The hinterland of Dubrovnik, well-known for its vineyards, fruit and vegetables, has been completely covered with illegal housing. The extent of agricultural land "consumption" in Dalmatia, Croatia and Yugoslavia can be fully appreciated if compared with the level of urbanisation in Great Britain. Out of the total area of the country, 81% is agricultural land. Though the level of urbanisation amounts to about 81%, London with the Middlesex counties occupies 76,000 ha with a total population of about 11 million while London alone has about 9 million.

There are many reasons that have led to the permanent loss of agricultural and arable surfaces to urbanisation, but the primary one is the geographic concentration of the population. Other causes include the attitude towards agriculture and rural areas in general, the parity of prices in agriculture, the euphoria of industrialisation and urbanisation, the problem of social insurance for farmers, taxation policy, the division of land into plots and speculation with it on the market. These factors cannot be investigated at length in this study but the principal causes have to be highlighted.

By 1961 already more than 50% of Dalmatia's population was non-agricultural. In the period from 1961 to 1981 about 250,000 of the agricultural population switched over to the non-agricultural category. Roughly speaking this is the equivalent of the present population of the town of Split.

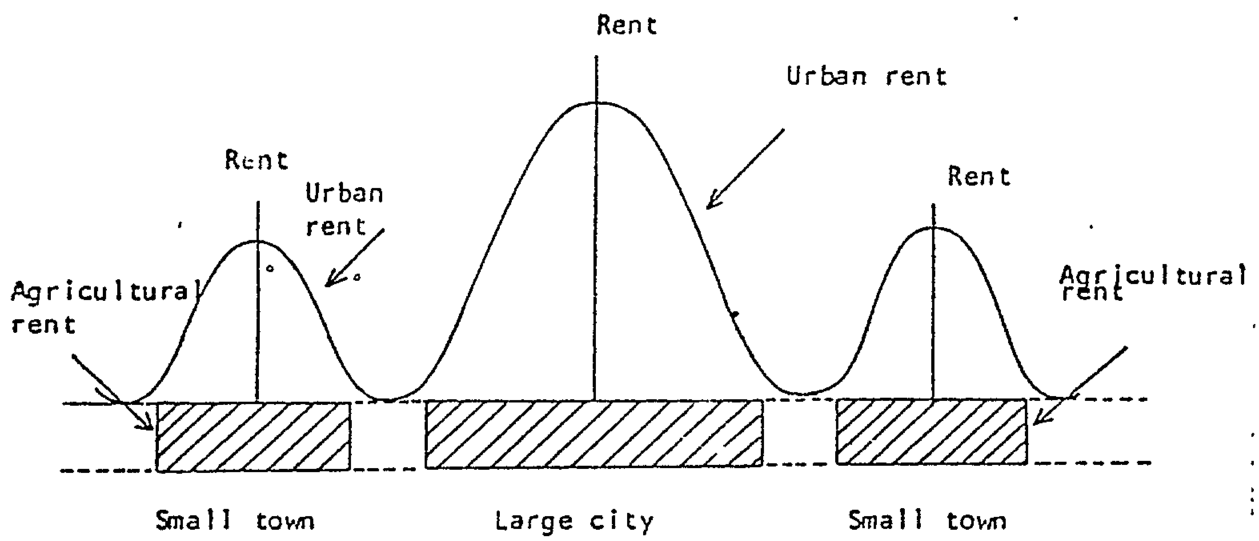
Since the Dalmatian towns were neither ready nor could they afford to accommodate and employ in an organised fashion and at short notice such a large number of people, the demand for plots for construction soared. This resulted in the accelerated division of land into plots which were sold on the private market. The price of plots went up enormously so that the price obtained for 1 ha of former agricultural land was equal to 100 annual cadastre incomes before taxation. This is unequivocally confirmed by calculating the economic value of the land on the basis of the dominant referral crop and the income obtained from 1 ha.

The sale of land for the local currency, the dinar, or for foreign exchange, became a profitable business. It was more profitable to keep the money in the bank and collect the interest on it than to cultivate a vineyard or olive grove and be exposed to all the risks of natural and "economic" disasters.

The sudden rise in the price of construction land opened up the process of giving priority to all forms of urban income at the expense of agricultural rent. Aside from traditional sources of income, new forms appeared: partnership, tenant, sub-tenant rent, rent from leasing and sub-leasing, tourist rent, etc. Due to the inadequate social security of farmers, only those that had no other choice appear to have remained on the land. Elderly households predominate in the rural areas and in the more remote parts exempt from the influence of the attraction of towns and tourist centres, land is being sold for next to nothing. Its value is barely two to three annual cadastre incomes.

The effect of the social division of labour manifests itself on the land through the law on rent "undulation". Economic rent is defined as a part of the surplus value per unit of land at a given period of time. In the Yugoslav Constitution this category is defined as the increased value of land as a result of various social interventions in space.

In the case of individual owners or beneficiaries of land who happen to be in such zones, the gains they make on the basis of what society (or someone else) has achieved constitutes unearned income and there is therefore no social justification for individuals to appropriate it. The influence of urban rent on agriculture can be illustrated as follows:



The law of "undulation" of rent begins from the town centre and reaches sometimes as far as the periphery in zones which are considered attractive (rightly or wrongly so). It is not difficult to see that the region of Dalmatia is such a zone. The rent undulates from Split towards Sibenik and Zadar in the North-West and towards Makarska and Dubrovnik in the South-East. In this region various types of income follow one another in wave-differentials, monopoly, absolute, tourist, leasing, partnership and other income, and the price is about 50,000 ha of agricultural land lost in the last twenty years alone.

There is no inevitable technical connection between industrialisation, urbanisation and agriculture. It is widely recognised that a large gap exists between incomes in towns and those in the countryside. The average per capita national income in urban areas is three times higher than in rural areas, the difference being somewhat lower in the case of smaller towns. This polarisation of incomes has led to the polarisation of prices of both agricultural and industrial products.

The cost of relocation of migrants is not sufficiently taken into account in the assessment of urban employment or of the benefits of labour-saving investment in agriculture. Failure to charge industrialists the full social costs of their operations, including pollution, congestion and the full economic price of land biases location and investment toward the cities. Above all, the concentration of political power gives cities a great advantage in the allocation of investment resources.

3. METHODOLOGY APPLIED

3.1 General methodological approach

Method as a system of logical procedures and positions constitutes a set of data, models and parameters for analysing and diagnosing the state of the art, defining the problem, formulating restraints and appropriate criteria for overcoming them.

In view of the subject of this analysis, "Protection of Agricultural Land from Non-Agricultural Uses in the Adriatic Coastal Zone" data need to be collected on the phenomena and processes affecting the transformation of agricultural into non-agricultural land.

Apart from its positive effects, urbanisation has had some negative effects too. Irrational forms of urbanisation have negative repercussions on the utilisation of primary resources such as arable land, water and energy. The "consumption" of agricultural land is the result of a combination of many factors including demographic, social, technological, institutional and political factors.

In this connection the appropriate data have been collected and consulted as well as the experience acquired by the author through many years of work in this field. They include:

(i) demographic: population trends, natural and mechanical increments, migratory trends, the state of problems in agricultural households, age and social structure of the population;

(ii) economic: employment trends, opening of work places, relations in the development of the primary, secondary and tertiary sectors of the economy, the parity of agricultural and industrial products, disparity in the economic evaluation of agricultural and non-agricultural resources, taxes, contributions, savings, distribution and consumption, ownership structure in agriculture, the effects of measures of land use, taxation, investment, crediting and other policies;

(iii) social: data on the social status of farmers, living conditions and standard of living in rural areas, the cultural environment, social security, segregation, integration, adaptation and the like;

(iv) technological: data on technological development, communication and information systems, application of the latest farming methods, to what extent the traditional gap between town and village has been bridged, whether the village has been integrated in overall development processes or whether it has been left aside;

(v) transportation: data on the development of public and private transport, the effect of public transport on the transformation of the traditional network into a system of settlements, regional development aspects, data for a comparative analysis, regional development aspects, data for a comparative analysis of public and private transport; social and ecological costs of geographic concentration of the population, negative external economies;

(vi) ecological: data on consumption of primary resources - land, irrational use of land, land population due to excessive use of pesticides and herbicides, the effect of solid and liquid waste on land devastation, price of primary technology, cost productivity of agricultural production and increase in ecological expenditures;

(vii) institutional: quality of planning and social plans, instruments parameters, personnel, institutions, methods and techniques, taxes and contributions on property, sale of property, income from property, on inheritance; budgetary mechanism and quality of administrative services and taxation organs; land cadastre and register, monitoring value of land and other real estate, cadastre revenue, rent, etc.

3.2 <u>Method of analysis of existing situation (impact analysis)</u>

Impact analysis comprises an assessment of direct and indirect effects of various measures and instruments which have both positive and negative consequences. There are numerous examples of the negative effects of such measures in terms of devastation of agricultural land.

1. Policy of protection of the standard of living of the urban population while life in the country is considered to be a part of folklore.

2. Policy of free formation of prices of industrial products while prices of agricultural products are under public control (purchasing price).

3. Far easier access to housing and consumer credits for the urban population.

4. The greatest share of investments is channelled into urban areas and non-agricultural activities.

   These and similar measures have a demoralising effect on the agricultural population who come to feel like second-rate citizens.

5. Taxation of sale of real estate is inspired by budgetary and fiscal opportunism rather than by the social and economic role of taxes. Land turn-over tax provides the municipalities' income. Recognising this and in order to increase their income it is in the "interest" of municipalities that land should be sold.

6. The taxation system gives the municipalities the possibility of levying lower taxes or exempting from tax land that is being sold for the purpose of agricultural production and imposing higher taxes on the sale of agricultural land for the purpose of building. Since these taxes constitute the municipalities' income the local authorities are not willing to renounce it and this has been an added incentive to the division of land into plots and their sale.

   Since land does not have a value, it is not thought to have a price either even though it is a limited economic source. In the absence of an operational social relationship towards land, instruments for its protection do not exist either.

7. Delay in the specialised services' reaction to various trends in the sale of land. Turnover tax should exclude the entire surplus value of the land. To do that they must know the normal economic value and the surplus value of land. For this purpose updated records, data processing and appropriate specialists are required.

8. Statistics are kept of wholesale and retail prices, manufacturers' and consumer prices but none on land prices. In civilized countries this is the responsibility of statistical offices and cadastres.

9. Land cadastres are not updated regularly. Though they are of special interest to society, cadastre services do not appear to participate in the process of elaboration of social and physical plans.

10. The investment of the urban population's savings into weekend homes while at the same time enjoying socially-owned flats in towns has had a devastating effect on the young generations in the rural areas.

    It is not so much because of those second homes themselves, because they know that it is easier for city dwellers to get a flat and credits under favourable terms for the purchase of durable consumer goods to holidays abroad, and on top of that they can purchase land and build second homes. This has had a negative demonstration effect. The village has started an inequitable competition with the city inspired by the craving for prestige while agricultural land is paying the price.

3.3 Methods of development of optimal land use models

3.3.1 Approach

Planned use of land for urbanisation should prevent the wasteful use of agricultural land by permitting development in appropriate areas only.

Land rent model should be the basis for the evaluation of various impacts on the use of agricultural land, particularly:

(a) the impact of urban growth on the determination of land price;

(b) the impact of urban growth on the transformation of agricultural land into built-up areas;

(c) the impact of the public authorities' planning decisions or urban land prices;

(d) the impact of urban growth on land allocation according to different uses in urban areas;

(e) The impact of socio-economic and urban growth on the value of land rent differentials and so on.

The value of urban land may be measured by the level of attractiveness of a human settlement. This is influenced by the variety of employment opportunities and the level of services. The level of land rent depends on various locational factors, dominant among them being the expected or actual income to be derived from structures built on the land surface.

A high standard level of economic, social and cultural services enhances a city's appeal and thereby its aggregate value and land rent. However, investment in urban infrastructure, in housing public and private services, working places and the recreational environment forms the basis of urban land value.

In rural areas, people invest money in agricultural land as well as in various amenities. The provision of infrastructural facilities in urban areas is the result of various interventions by society through planning decisions so as to switch from agricultural to urban land use. The additional value generated in this way not only exceeds the cost of the infrastructure but could also cover the costs of social services - schools, social welfare, health care and still leave a large surplus in the hands of the owner and user of the newly urbanised land. A comparison of the prices of land as such, the costs of infrastructure and the price of land in urban areas in the Dalmatian coastal zone indicates that the new urban value is 5 to 6 times higher than the costs of infrastructure in the case of residential land and 10-20 times higher in the case of land for commercial use.

The demand for urban land by far exceeds supply. As a result, urban land income is much higher than agricultural income, as much as 200 or 500 times higher. The income from urban land is an aggregate of agricultural land price, plus development costs, plus surplus value (value above normal cost or normal income) due to the far greater attractiveness of urban areas. The problem is in the surplus value of urban land which is partly the result of economic investment in urban areas and partly the result of the syphoning-off

of the value of agricultural land income into the cities. If the relations between town and village, agriculture and non-agriculture and the like are not based on sound economic criteria, the added value (surplus value - unearned income) constitutes for many city dwellers windfall gains. Given identical conditions (ceteris paribus) only a social division of labour in the broad sense together with an efficient institutional and planning mechanism could determine the relationship between agricultural and non-agricultural land. Otherwise windfall gains are one of the essential factors contributing to the irrational transformation of agricultural land into built-up land.

3.3.2 *Method*

The method of optimal land use can be elaborated through a combination of different sub-models such as "impact analysis", "cost/benefit analysis" and "land use coefficients".

The basis of the method is to be found in the principles of cost/benefit analysis based on opportunity studies which start from alternative uses of resources for different purposes and from the evaluation of external effects, i.e. external benefits and gains.

The alternative use of resources on the basis of criteria of individual and social marginal profitability should show what the individual, household, local community, municipality, region, etc. stand to gain and what they stand to lose from the transformation of agricultural land into building land.

An evaluation of external economies and dis-economies (positive and negative externalities) points to a divergence between individual and social benefits which manifest themselves in the long range as social costs in the sense of the irrational loss of agriculture land in favour of built-up land.

A rough estimation of alternative patterns of urban growth and alternative land use in rural areas has shown that the process of urbanisation has been extended at the expense of agricultural space. Both types of land (urban and rural) are being used in a sub-optimal way which means that every extension of the built-up area must be based on project evaluation. Cost/benefit calculations should be supported by an assessment of other impacts such as those on income, employment, cost of living, cost of reduction of land revenue in agriculture, cost of urbanisation, loss of revenue by households, local municipalities and society as a whole.

On the basis of the results obtained and with the help of land use coefficients for particular, primarily, urban purposes, various policies are defined - land, taxation, planning or legislation and regulations which provide an analytical framework for the development of urbanisation and the protection of agricultural land. Practices in the developed countries - the Netherlands, Sweden, Britain, France - provide eloquent evidence of this.

By applying land use coefficients for urban purposes, the needs for space are defined. The change in pragmatic parameters of area in m^2 per inhabitant indicates that the entire urban population of Dalmatia could be accommodated on 6-8,000 ha.

3.4 Method of selection and assessment of various agricultural land protection measures

Various measures for directing and controlling land use policy in urban and rural areas may be broken down into several categories. The most important among them are: land register, planning measures for land use, public land development policy, regional development, taxation methods and direct intervention by the public authority.

3.4.1 Land register

(a) Land mapping in which all the necessary information is collected regarding locational characteristics of each site, size, use, ownership and value. Land use, land ownership and land value must be regularly updated.

(b) Formulation of sound criteria for assessing the economic value of urban and agricultural land. The criteria should be based on economic and market value. Under these conditions the public authority is in a position to assess the current value of the land irrespective of who is the owner or the user of that land: a public authority, organisations, enterprises, individual farmers or a private individual. Regular evaluation should be based on the general trends in land prices, transactions around the urban area, the economic value of agricultural land in the remote areas and on the economic costs of the urban infrastructure.

(c) Specialised training is required for land evaluation and land register management.

(d) Land use mapping should serve as a basis for land use planning.

(e) All owners or users of land are obliged to declare all changes to the value of their land every year or at least every two years. This information serves as a basis for taxation, compensation or expropriation.

3.4.2 Land use planning measures

(a) Macro and micro zoning should be applied at each level of planning - national, regional and local. Within this framework, the use of land should be designated: agriculture, recreation, weekend homes, urban land and land reserved for future urban development. Zoning plans should be revised every 10 years on the basis of urban and rural development schemes.

(b) All changes in land use should be prohibited. The responsible institutions should be qualified to forecast all changes in population growth and economic development so as to provide, on time, land for urbanisation, bearing in mind the need to protect agricultural land.

(c) Land should be used according to development programmes and in connection with land development schemes. All the necessary planning activities, including changes in ownership as a result of expropriation or compensation should be completed within a maximum period of five years.

(d) Inhabitants of rural areas should enjoy a priority right to purchase land which has not been earmarked for urban development.

(e) Planning authorities and institutions should elaborate and define land use coefficients, norms and standards and improve economic and social criteria for land allocation according to different uses. For the evaluation of these parameters and criteria, methods such as "impact analysis" and "cost/benefit analysis" should be used.

3.4.3 Public land development policy

(a) Responsible institutions should investigate and formulate alternative forms of compensation for the landowners such as construction permits, improvement and enlargement of individual farm areas instead of relying exclusively on monetary payment.

(b) In order to improve the quality of the environment, the physical and social infrastructure should be promoted. Departure from the rural areas has not always been motivated by economic factors. In many cases the attractions of the big city are more important reasons for young people to migrate, not only from rural areas, but even from small towns.

3.4.4 Regional development

In selected rural areas, agro-industrial centres should be established in which industrial enterprises for processing agricultural produce would be concentrated and which would serve as a basis for educational activities to train qualified personnel to act as instructors with a view to modernising agricultural production. These centres should develop housing projects and cultural institutions for the staff.

3.4.5 Taxation methods

(a) A tax on changes in land use should be established in order to prevent agricultural land being transformed into urban land.

(b) A land profit tax should be introduced according to the level of profit based on the difference between the normal economic value of land and its selling price. Purchasing prices should be adjusted to the consumer price index.

(c) Periodic evaluations of declared selling price and the prevailing market price should be introduced. Appropriate institutions should be assigned the task of regularly collecting information on land price trends.

(d) A property tax on commercial land use which would be several times higher than the property tax on residential land use should be introduced.

(e) A progressive taxation rate should be introduced depending on the turnover of commercial enterprises. It should be higher for banks, insurance companies and foreign trade firms and lower for the retail trade and services.

(f) In order to equalise living conditions in urban and in rural areas, inhabitants of urban areas should be obliged to finance infrastructural works and to pay the full economic price of roads, sewerage, water supply and the like.

3.4.6 Direct measures by the Public Authority

(a) In urban areas, built-up land should be leased directly to the landuser, i.e. the residents, commercial or industrial firms. Building societies should not enjoy any land use rights, not even for a transitional period.

(b) The evaluation of land value for the users should be based on socio-economic criteria. This estimate should be based on the price of the land in agricultural use plus the costs of the physical infrastructure which should be calculated separately and not automatically included in housing and other land use costs. The price of the land should take into account the locational factor primarily as regards the ease of access to city functions.

4. RESULTS OF THE PROJECT

The development of socio-economic processes and the technological changes in the region of Dalmatia, in addition to their positive effects, have had some definitive negative effects primarily as regards the loss of agricultural land. In the last 10-15 years alone, due to disorganised urbanisation, about 1,000 ha of agricultural land was lost every year on average. According to town planning standards and coefficients of land use for various types of construction, it is evident that the entire urban population could have been accommodated in a far smaller amount of space while valuable agricultural land could have been preserved.

Apart from the loss of land for agriculture the adverse effects of irrational urbanisation have been reflected in the multifold increase of costs of rural and urban infrastructure. Under conditions of uneconomic organisation of land use, the costs of utilities, particularly sewerage, have increased abruptly. Waste water disposal has become more and more expensive so that it is mainly left to individual private builders to deal with the problem as a result of which the necessary systems are built without any social control. The collection and treatment of solid and liquid waste is a major problem for the whole of Dalmatia but particularly for its coastal zone.

The reduction of agricultural land has partly resulted in the decline of olive growing and viticulture. The decrease in production has compensated to some extent by the increase of yields per unit (per 1 ha) thanks to the application of the latest technology but also, unfortunately, to the excessive use of chemicals which, in the long run, have a devastating effect on the natural qualities of agricultural soil. Uncontrolled expansion of settlements and the excessive use of pesticides and herbicides destroy the ecological equilibrium between nature and society.

Existing laws and regulations, though extensive, have not been adequately placed in the service of the protection of agricultural land. The shortcomings are evident both in terms of the lack of detailed elaborations and codification of individual laws. An impact analysis clearly reveals the

lack of correspondence between individual laws. For instance, according to the Law on the Protection of Agricultural Land, this land is protected while, according to the Law on the Sale of Real Estate, its sale and change of use are permitted. According to the Law on Physical Planning and Development in spatial plans, agricultural land has to be allocated exclusively for agricultural production. However, the turnover tax on land and other real estate provides the municipalities' revenue or budget so that the local authorities have a vested interest in increasing their earnings through increased trading of land.

Master plans insist on reducing distances between people's place of work and residence. On the other hand, incentives for the purchase of private cars are encouraging individuals and households to live in settlements that are removed from the centre of activities. Ecological legislation seeks to protect the human environment so that it would be natural to encourage the development of public rather than private transport. The actual trends are quite the opposite. Dubrovnik has in the meantime even eliminated trams and replaced them with buses. As a result, noise and air pollution levels have been increased several times over.

So that, in the desire to achieve immediate results - in this case buses are more flexible and faster - high social and ecological expenses have been incurred.

Similarly, the disparity of prices between industry and agriculture has been at the exclusive expense of the latter resulting not only in a loss of faith, but also in the loss of opportunities for agricultural production, which has led, among other things, to the exodus of people from the countryside and to the division of land into plots for building and the subsequent sale of agricultural land.

The conflict between agricultural and building land is manifested in the conflict between agricultural and building rent. Since agricultural land has been artificially devalued and building land extremely overvalued, the result is sub-optimal use of land at the expense of agriculture. Since real economic categories are not operational in towns for various reasons - housing rent, depreciation of housing and infrastructural funds, public transportation fares - the economic value of building land and of housing and infrastructural funds is being syphoned off unawares into household budgets and through them dispersed in the suburbs on the basis of demand for building plots whereby the value of agricultural land is increased as it is transformed into land for building. The pressure of building rent on agricultural land undermines stability and suppresses the initiative of the agricultural population which has in fact led them to abandon agriculture.

5. POSSIBILITIES OF APPLYING OBTAINED RESULTS TO OTHER MEDITERRANEAN AREAS

On the basis of studies, experiences and data, differences and similarities among the Mediterranean countries can be identified with respect to existing relations on the land. The differences are mainly in the area of socio-economic relations, the level of economic development, the structure of the economy, the level of urbanisation and motorisation, the way of life, the activities the population engages in, land ownership and land use tenure. The

differences are particularly pronounced in land tenure systems between those countries that used to be under the Ottoman Empire and those whose legal systems are based on Roman Law.

In the countries of the former Ottoman Empire, private land ownership rights (mulk) exist side by side with other forms such as state land (miri), land which cannot be alienated from the possession of the owner (waqh) and collectively-owned land (musha).

The political structure of a country in addition to its socio-economic system and historical pattern of development influences the balance between collective and individual land-use rights. The Constitutions of different Mediterranean states vary with respect of the rights of the State. The Constitutions of Italy and Spain for instance, specifically indicate that the right of private land use is limited when it conflicts with the public interest and they stress the social character of land. In Yugoslav cities, social land ownership is the dominant form. In many countries there is a mixture of the traditional - communal and modern concept of private ownership.

Apart from the differences there are many similarities among virtually all the Mediterranean countries. The coastal zones in all these countries are under pressure of high demand for building land. In these zones industry, tourism, transport and various services are developing intensively. One of the consequences of this development is the loss of agricultural land and sea and air pollution. All countries, some with more and some with less success, are investing efforts to channel the above-mentioned processes in the desired direction. Nonetheless, unfavourable consequences appear to outnumber the favourable ones.

In this connection it would be useful to undertake investigations in a number of typical Mediterranean regions similar to Dalmatia and, on the basis of the findings, to make some general conclusions which could serve as a basis for the elaboration of appropriate measures and actions. The critical points of these investigations would be land cadastres and registers, data bases, methods of economic and ecological evaluation of land and other natural resources, price of development and personnel. Such research projects would be helpful for the national and regional authorities to promote their legislation, regulations, planning, taxation mechanisms and land use policies and in the aim of land soil protection.

It would be useful if PAP could elaborate a practical framework for investigations and coordinate the entire project.

6. CONCLUSIONS, RECOMMENDATIONS AND SUGGESTIONS

6.1 Conclusions

In the Dalmatian region, the private land market functions in a way that is similar to many other regions in Mediterranean countries. There are, however, important differences in the degree of the problem created by the private land market and in the ability of administrative institutions to respond to the problems. The rate of urban population growth, as well as urban concentration is very high in Mediterranean coastal zones. Because of high inflation rates, lack of alternative investments, and weak taxation and planning systems, investment in land is more attractive in Mediterranean

coastal regions. Speculative holding of land, with greater increases in land prices, vacant land squatter settlements, all demonstrate that the land supply has not been able to meet the demand at an acceptable price. Some of the measures proposed may be of use in dealing with these problems.

Firstly, measures should be taken to influence the private land market and restrain the high rate of increase in land prices that is making land too expensive for large sectors of the population. This measure depends on the existence of accurate valuation and assessment machinery for the preparation of an up-to-date land register. Without such information urban and agricultural land use control measures will be ineffective. The costs of land register are lower than the taxation of land profits. Land evaluation is also one of the basic elements for paying compensation and shortening the legal procedure in the case of expropriation. Land register would show exactly the size of the land parcel, the ownership of the site, and the price of the land over different time periods. This document must be published in special maps allowing taxes to be collected according to real land values. The work of the evaluators would be controlled by the public, which could compare the land value map with the real land price in the market.

Secondly, there should be measures concerning stricter and more comprehensive zoning control and the taxation of land profits. The objective of the first is to limit the areas that are affected by pressure for speculative land purchases; the taxation of land profits seeks to reduce the rewards of investing in land. According to comprehensive-macro-zoning schemes for the whole region within the country, the areas must be permanently restricted to agriculture, for future urban development, tourism, transportation and so on. Taxation is one of the ways to restrict the increase in land prices and to transfer a surplus value of land created through urban growth to the community. The lack of permanent land price evaluation or of a system to control evaluation through publishing land value maps, has prevented taxes from being collected according to the official established rates.

6.2 Recommendations

The phenomenon of urbanisation has prompted cities to occupy arable land and thereby threaten food supplies. Integrated land use policies are designed to resolve the basic competition between urban and agricultural users. Because it is a unique resource, land needs careful husbanding. Urban and non-urban uses of land are mutually interdependent. The right and obligation of the respective authority is to provide careful planning for human settlements and sound environmental utilisation. Settlements everywhere inherently reflect social and cultural attitudes towards the effective use of land.

In order to implement these goals and tasks, the respective government should undertake various measures in land-use planning, by improving taxation methods, by direct intervention, land mapping, public land development policy, a policy for land use within the city, and regional development.

(a) Land-use planning is related to macro and micro-zoning, land prices, elaboration of detailed planning scheme, priority purchase right, enabling the local farmer to purchase agricultural land, formulation of norms and standard for land use.

(b) Taxation methods would be efficient enough to recapture surplus value of land which is created by various governmental and community intervention in land such as: utility services and transportation, social overheads (schools, open spaces), or through the general growth of the community in numbers, income and activities, which provide a basis for the demand of land.

(c) Direct intervention, first of all means the establishment of a special fund made up of income from land disposal, taxation revenue and special government loans with the purpose of providing land in advance for urban development and for recovery of agricultural land.

(d) Land-use mapping should serve as a basis for land-use planning, compensation, expropriation and taxation.

(e) Public land-development policy might include an alternative form of compensation and in combinations of different methods of development: low-cost housing, site servicing schemes, tax exemptions and low land prices would encourage industries and commercial services to move from the big city to the small settlements.

(f) Policy for land use within the cities should be directed to rationalise criteria and coefficients of land allocations for different types of use: residential, transport, industry, green space, the service sector and the like.

(g) The role of the regional authority should be to coordinate the land development departments of the municipalities in the region. At the same time the regional authority should act as an executive agency for some smaller municipalities that are unwilling or unable to organise land development departments.

7. BIBLIOGRAPHY

1. Report of Habitat: United Nations Conference on Human Settlements (U.N. 1976); and U.N. General Assembly Resolution 32/162.

2. L. Gertler, "Habitant and Land, Human Settlement Issues 1", Vancouver University of British Columbia Press, 1978.

3. R.W. Archer, "Urban plan and the Property Market : Notes for a Course of Lectures", 1971.

4. N. Lichfield and H. Darin-Drabkin, "Land Policy for Planning", London: Allen and Unwin.

5. N. Lichfield, "Towards an Acceptable Planning System", Town Planning Review, 1979.

6. D.R. Denman and S. Prodano, "Land Use - An Introduction to Proprietary Land Use Analysis, London: Allen and Unwin, 1972.

7. "Land for Human Settlements", United Nations - Some Legal and Economic Issues, United Nations, 1977.

PROTECTION DES TERRES AGRICOLES CONTRE L'UTILISATION NON AGRICOLE DANS LES ZONES COTIERES (TUNISIE)

par

H. BACCAR et A. HENTATI
Ministère de l'Agriculture
Tunis, Tunisie

1. INTRODUCTION

Les zones côtières tunisiennes ont constitué depuis fort longtemps des foyers économiques très actifs et prospères. Les activités agricoles y étaient bien développées grâce à l'extension des plaines facilement accessibles constituées de sols relativement fertiles. Les villes littorales, qui étaient à l'origine d'anciens comptoirs trans-méditerranéens et qui ont joué un rôle important dans les échanges commerciaux entre les villes méditerranéennes et les régions africaines au sud du Sahara, ont connu un grand essor économique et sont devenues de véritables pôles de développement nationaux et régionaux. Par leur rythme de développement très accéléré par rapport aux villes de l'intérieur, elles ont pu drainer la majorité des efforts de développement économique et social consentis par la Nation depuis le début de l'Indépendance (1956). Ainsi, elles bénéficient des principales infrastructures de communication et d'équipement dont l'implantation était nécessaire pour promouvoir les activités industrielles et touristiques qui ont connu un grand essor dès les années soixante-dix.

Le dynamisme des villes littorales a favorisé l'attraction des populations rurales de l'intérieur. En effet l'exode rural, qui était très actif durant les deux dernières décennies, a contribué énormément au gonflement des effectifs de population de ces villes. Celles-ci se sont étendues anarchiquement aux dépens des terres agricoles fertiles qui assuraient l'approvisionnement quotidien des marchés de ces villes en produits agricoles maraîchers et potagers.

Un déséquilibre économique et social local commence à apparaître dans les zones littorales périurbaines, manifesté par la détérioration du cadre de vie des villes, par la prolifération des quartiers sous-intégrés et la dépendance de plus en plus grande des marchés de ces villes de régions plus lointaines dans leur approvisionnement en produits agricoles quotidiens.

Ce déséquilibre constitue une source de détérioration de l'environnement des zones côtières que cette note se propose d'étudier à partir d'une analyse historique, géographique et socio-économique de l'extension des utilisations non agricoles aux dépens de l'utilisation agricole des terres dans les zones côtières de la Tunisie.

2. LA SAUVEGARDE ET LA CONSERVATION DES SOLS : ELEMENTS FONDAMENTAUX DANS LA PROTECTION DE L'ENVIRONNEMENT

Les pays méditerranéens sont pour la plupart compris dans la zone climatique subtropicale. Cette zone se caractérise par des écosystèmes fragiles dont les composantes essentielles, à savoir le couvert végétal et les sols, sont héritées depuis les dernières périodes pluviales du Quaternaire. Les conditions climatiques actuelles, dominées par la sécheresse et l'aridité, ne permettent pas une régénération naturelle facile des formations végétales et ne favorisent pas la pédogenèse. Au contraire, par le caractère irrégulier et torrentiel des pluies ainsi que par l'omniprésence des vents violents, les processus de morphogenèse sont plus actifs et entraînent une dégradation de plus en plus poussée des sols. En effet, vue l'ancienneté de l'occupation humaine des pays méditerranéens et notamment de leurs zones côtières, la couverture végétale naturelle a subi des pressions très fortes qui l'ont décimée en majorité. Seules quelques vestiges de forêts climaciques subsistent encore, accrochés aux hauts sommets des montagnes. La dénudation des reliefs, catalysée par une gestion inadaptée de l'espace par les populations, la torrentialité des pluies et la grande vitesse des vents, a permis l'accélération des processus d'érosion et de désertification. Ainsi des centaines de milliers d'hectares de sols sont perdus annuellement depuis déjà des siècles. L'impact de ce phénomène sur l'économie des pays méditerranéens est grand puisque la majorité de ces derniers basent leur subsistance sur les activités agricoles et la production de la terre. Celle-ci étant soutenue par des sols hérités, donc non renouvelables, leur dégradation et perte entraînent une chute de la production agricole. Les conséquences sont graves puisqu'elles ont des dimensions politiques, sociales, économiques et civilisationnelles même.

C'est pour ces raisons que les efforts de lutte contre la désertification et l'érosion sont très anciens dans les pays méditerranéens. En Tunisie ces efforts datent depuis les civilisations anciennes qui ont laissé des traces de travaux de conservation des eaux et du sol.

Les efforts déployés actuellement en Tunisie dans ce domaine sont très grands puisqu'ils traitent aussi bien le niveau technique et scientifique que le niveau législatif, social et politique. Un budget conséquent a été alloué aux travaux de lutte contre l'érosion et la désertification depuis l'indépendance (1956). Des acquis considérables ont été réalisés.

Toutefois, les terres agricoles subissent également l'agression des utilisations non agricoles et c'est cet aspect là qui n'a pas été bien circonscrit. Les pouvoirs publics n'ont réagi contre ce phénomène que récemment quand les questions de protection de l'environnement ont commencé à prendre de l'importance au niveau national et international. Les sensibilisations effectuées par les organisations régionales et internationales sur les risques de détérioration de l'environnement suite à la dégradation des terres ont joué beaucoup pour persuader les pouvoirs publics de prendre les mesures nécessaires afin de sauvegarder les ressources en terres agricoles. C'est dans ce cadre que s'inscrivent les efforts déployés par le PNUE, le CAR/PAP et autres organisations et pays à travers le monde. Une présentation du phénomène de perte des terres par les utilisations non agricoles dans les pays du monde permet de le dimensionner et de connaître son ampleur.

3. LA PERTE DES TERRES AGRICOLES PAR LES UTILISATIONS NON AGRICOLES DANS LE MONDE ET EN MEDITERRANEE

3.1 Dimensions du phénomène dans le monde

Les besoins en terre pour l'utilisation non agricole concernent les espaces réservés à l'urbanisation, aux voies de communication, aux installations industrielles et d'extraction minière, à la sauvegarde de ces installations, aux besoins récréatifs et à la sauvegarde de l'environnement et du cadre de vie des agglomérations existantes. Ces besoins non agricoles sont indispensables pour asseoir une vie équilibrée des sociétés locales, et de ce fait ne dépendent pas des voeux des populations, mais ont été imposés à la fois par les considérations écologiques, les pressions humaines et les méthodes d'utilisation des terres.

Seulement, dans les régions à économie urbaine très prospère par rapport à leur environnement rural, la demande en terre pour les utilisations non agricoles s'est accrue selon des proportions très grandes qui dépassent de loin les normes d'équilibre, ce qui s'est traduit par une agression par moment brutale des terres agricoles. Ces régions présentent les cas extrêmes d'utilisation des terres pour les besoins non agricoles. A l'opposé, il existe des régions où ces types d'utilisation sont en-deçà des demandes réelles obligées par leurs potentialités économiques. Les études de cas montrent que le pourcentage des terres accaparées par les utilisations non agricoles par rapport à la superficie totale varie de 0 à 33%, en fonction des régions et des types d'utilisation des ressources offertes.

L'étude détaillée d'une vaste zone irriguée en Malaisie (Wong, 1977) a montré que les besoins réels de chaque habitant en terres à utilisation non agricole sont d'environ 500 m^2, ce qui est relativement élevé.

Aux Etats-Unis ces besoins varient de 2500 m^2 dans la région de New England à 300 m^2 pour l'agglomération de New York (Spenlding et O'Heady, 1977).

Pour certains pays africains, ces besoins varient de 10 m^2 par habitant dans les régions humides (Nigeria - Cameroun) à 240 m^2/habitant dans les régions subhumides à semi arides caractérisées par des densités d'habitants plus élevées (Hyde <u>et al.</u>, 1980).

Les études menées par le PNUO (1981) au Bengladesch ont montré que l'extension des terres pour les utilisations non agricoles étaient de 7,7% entre 1952 et 1974 malgré une augmentation de l'effectif des populations de l'ordre de 58%. Il y a eu au début une densification des espaces non agricoles existants et actuellement, toute augmentation de population va entraîner un grignotage accéléré des terres agricoles environnantes.

Les besoins de chaque habitant en terre pour les utilisations non agricoles étaient estimés par ces études en moyenne à 270 m^2 au Bengladesch dans les années cinquante, passant à 180 m^2 seulement en 1974.

Ainsi, ces besoins sont intimement liés au dynamisme économique et au rythme de l'évolution sociale de chaque pays et région.

D'autre part, pour apprécier le volume des terres destinées à des utilisations non agricoles dans le monde, la F.A.O. a entrepris une étude en 1981 basée sur les estimations des surfaces occupées par les constructions disponibles dans 41 pays. Cette étude montre que le chiffre moyen de la part de chaque habitant en terre construite est de 560 m^2 pour l'ensemble de ces pays. Ce chiffre moyen cache des différences énormes. En effet, en Ouganda par exemple où l'urbanisation est relativement faible, la part de chaque habitant en terrain accaparé par les constructions est de 440 m^2. Ce chiffre s'élève à 780 m^2 en Nouvelle-Zélande et à 800 m^2 en Colombie, caractérisés par leur forte urbanisation.

En outre, cette étude a également indiqué que l'augmentation des surfaces construites enregistrée entre 1979 et 1980 pour l'ensemble des pays étudiés était moyenne, mais les disparités entre les régions dans chaque pays sont énormes, et il faut en tenir compte dans l'estimation exacte de l'impact des extensions inconsidérées des constructions sur la valeur agricole des terres.

Cependant, vu les aspects variés de la question et les difficultés qu'il y a à déterminer les besoins objectifs de chaque habitant en terre pour les utilisations non agricoles, la F.A.O. a retenu le chiffre de 500 m^2/habitant pour établir son étude sur les potentialités des terres à nourrir les populations dans le monde en développement dans le cadre du projet, "Ressources de la terre pour les populations futures". Le chiffre de 500 m^2/habitant paraît coincider avec les estimations faites aux Etats-Unis et dans d'autres pays du monde.

Toutefois, pour certaines régions à économie très dynamique, la pression des utilisations non agricoles sur les terres de culture est de plus en plus grande. En effet, pour le Royaume-Uni, on a estimé qu'au cours des prochaines années il faudrait 9000 km2 de terres supplémentaires pour y construire les habitations prévues en fonction des critères d'urbanisme modernes; or les villes s'étendent dans les plaines et les endroits particulièrement accessibles: cela équivaut donc à sacrifier l'équivalent de trois comtés moyens, c'est-à-dire 10% de la surface actuellement cultivée. D'autre part on estime que, lorsque toute la population des villes anglaises actuelles sera relogée dans de bonnes conditions, 1/6 des plaines cultivées sera couvert par les constructions urbaines. D'après les estimations faites vers la fin des années soixante-dix, en Angleterre - pays de Galles, les villes occupent plus de 10% de la superficie totale; dans les quatre régions les plus urbanisées du pays, les pourcentages atteignent des valeurs alarmantes: 13% dans les Midlands de l'Ouest, 14% dans l'Ouest et l'Est des Ridings du Yorkshire, 29% en Lancashire-Cheshire, 35% dans le Sud-Est anglais.

Ces proportions sont appelées à augmenter davantage. L'extension inconsidérée des villes voisines par la progression et l'étalement de leurs banlieues au fil des années aboutit à la jonction de ces banlieues et des villes voisines, donnant lieu à une grande tache d'espace bétonné que les géographes appellent à juste titre "conurbation". Le Royaume-Uni a connu la constitution de plusieurs conurbations développées, surtout lors de l'expansion industrielle dans les régions minières et les villes portuaires. La conurbation de Glasgow est un exemple représentatif de l'évolution de l'urbanisation aux dépens des terres agricoles au Royaume-Uni (Fig. 1).

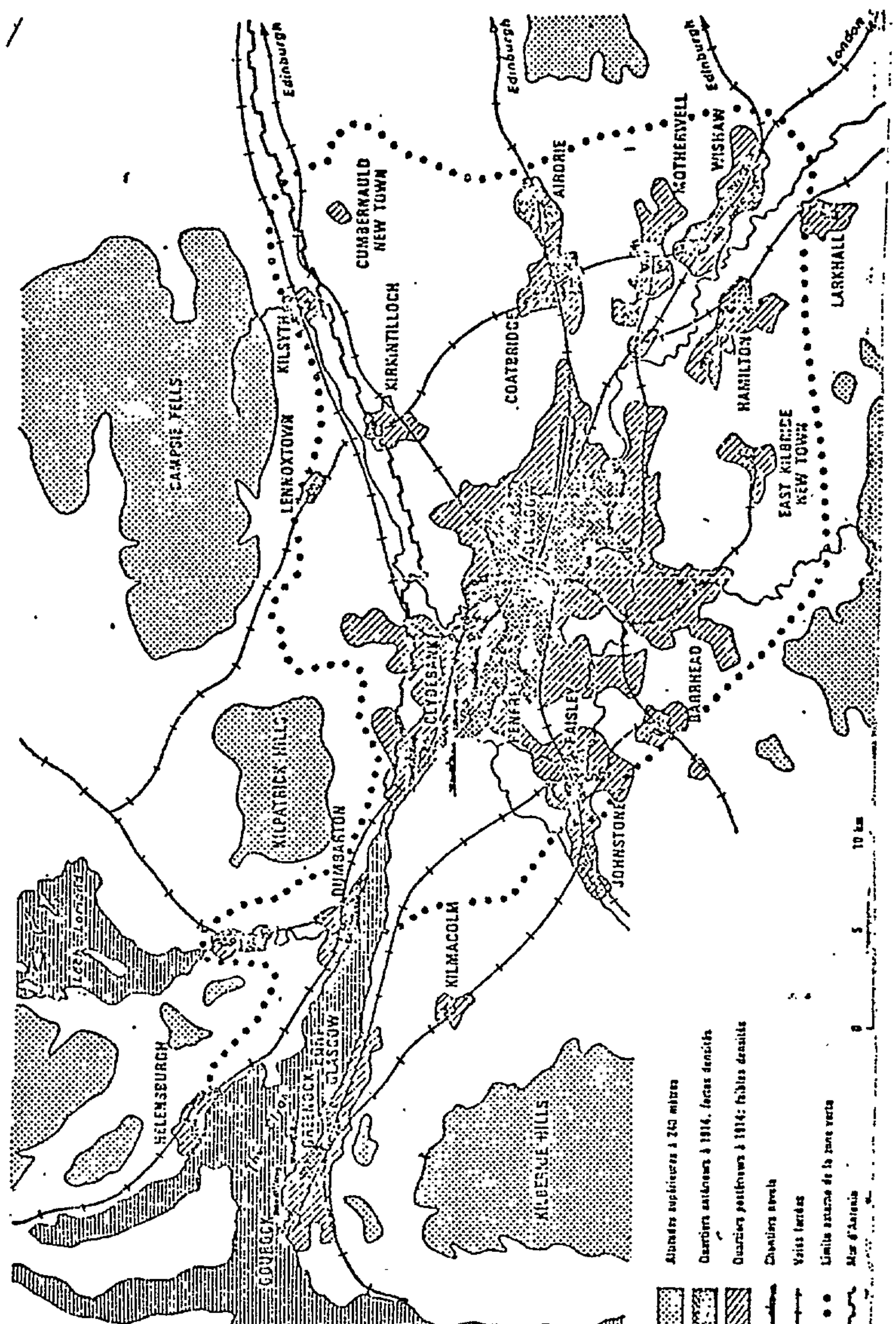


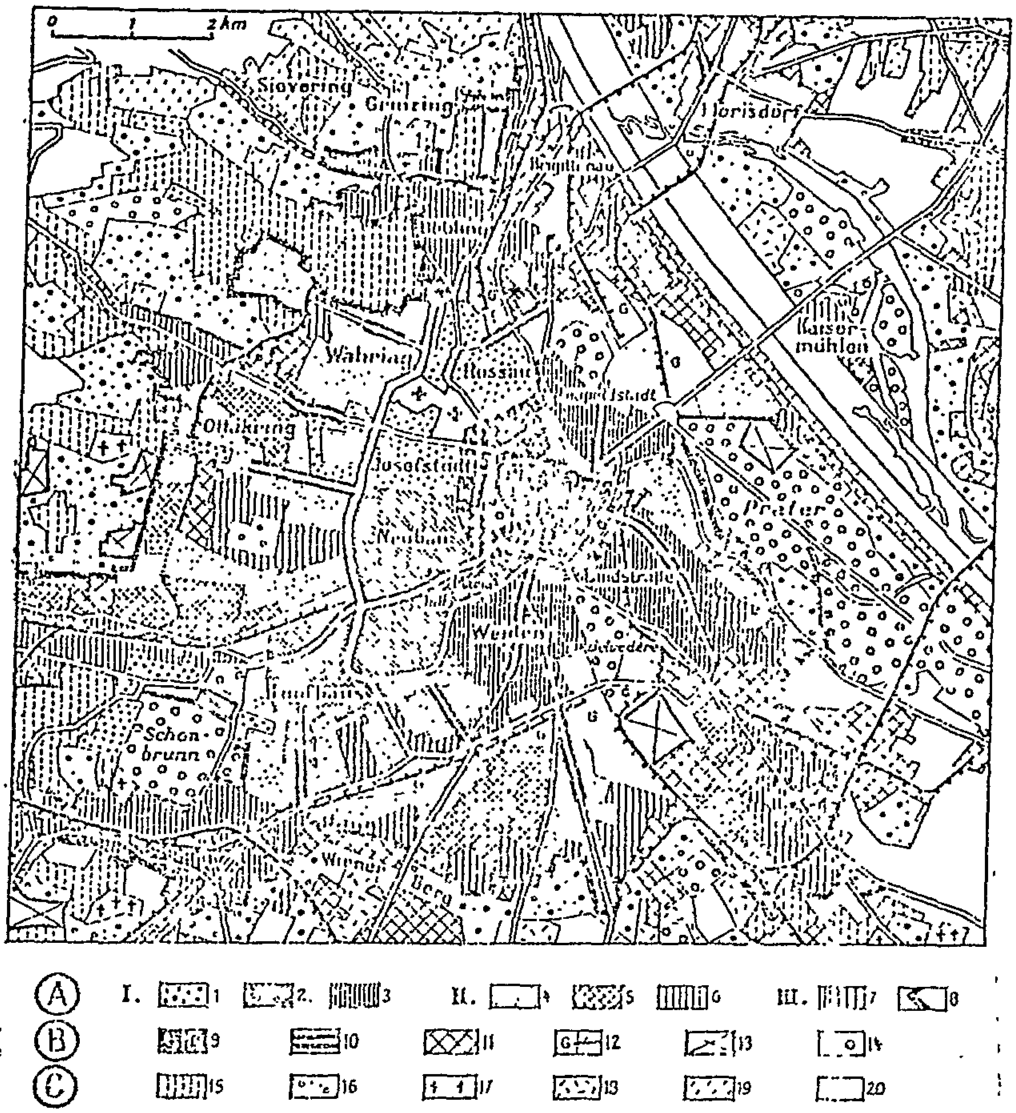
Fig.1 La conurbation de Glasgow : état actuel

Le dynamisme des conurbations au Royaume-Uni a fait que l'agriculture dans le pays de Galles a déjà abandonné un million d'hectares de 1900 à 1960; de 1960 à l'an 2000, elle livrera encore vraisemblablement 900.000 hectares. Les pertes en terres agricoles étaient très grandes pendant les années 1930-1940, alors que le prix du sol tombait à des valeurs très basses, que l'explosion urbaine longtemps contenue faute de moyens de transports rapides se déchaînait souvent. Ensuite, pendant la période de 1946 à 1962, l'agriculture britannique a cédé en moyenne chaque année 15.000 hectares à la construction, 9000 hectares au reboisement. Les milieux agricoles anglais résument ainsi la situation: une ferme est engloutie par jour. Pour endiguer cette situation alarmante, tout un arsenal juridique sans cesse étoffé et amélioré a été mis en place dans ce but depuis le début du siècle. En effet, en 1909, la planification urbaine fut officialisée par une loi qui faisait passer le sens de l'intérêt public avant les projets individuels. Em 1940 le rapport présenté par la Commission Barbow concluait à la nécessité impérieuse "d'arrêter la croissance désordonnée des grandes villes". En 1943 fut créé en Angleterre le premier Ministère de la Planification des villes et des campagnes. Ensuite, une série de lois tendant à contrôler l'affectation des terres furent promulguées au Royaume-Uni: loi de 1945 réglementant la localisation de l'industrie; loi de 1946 sur les villes nouvelles; loi de 1947 sur l'aménagement du territoire; loi de 1952 sur le développement des petites villes, loi de 1956 sur les subventions à la construction, lois de 1958, 1960, 1963 sur la localisation de l'emploi, loi de 1965 sur le développement de l'industrie et du secteur administratif; etc. Mais malgré cet arsenal législatif, le contrôle de l'utilisation de l'espace national par les pouvoirs publics et les municipalités n'est pas encore parfait. Les conflits entre utilisateurs qui convoitent la même parcelle de terre n'ont pas tous été éliminés, le phénomène d'étalement des villes aux dépens des terres de culture n'est pas complètement enrayé. Néanmoins, il n'y a qu'un seul pays au monde, les Pays-Bas, qui ait su faire mieux que la Grande-Bretagne en matière d'utilisation optimale du sol. Mais l'expérience acquise par la Grande-Bretagne, notamment par sa politique d'aménagement axée sur le développement des villes satellites et de villes nouvelles, a une valeur d'exemple. Ce sont toutes ces raisons qui justifient cette longue analyse du conflit entre l'utilisation non agricole et l'utilisation agricole des terres.

Cependant, ce phénomène est également saisissant dans les autres pays d'Europe qui constituent le continent relativement le plus urbanisé. L'exemple de l'extension de la ville de Vienne présente un exemple frappant puisque cette ville centre une région agricole très riche (Fig. 2). L'espace bâti de cette ville a augmenté de trois fois entre 1840 et 1918, et de plus de 12 fois entre 1840 et la dernière décennie.

En France, on estime qu'il faudrait bâtir au cours des dix prochaines années un nombre de logements équivalent à celui contenu actuellement dans l'agglomération parisienne soit environ 1000 km^2. Où implanter ces nouvelles habitations ? Faut-il sacrifier les dernières terres de cultures qui forment encore des espaces verts entre les tentacules de l'agglomération parisienne ?

Ainsi, la pression urbaine sur les terres agricoles en France ne cesse de s'accentuer.



(D'après Élizabeth LICHTENBERGER, *Atlas d'Autriche*, et *Geographische Rundschau*, jui 1962; cartes VI, 0 et VI, II (H. Bobek et E. Lichtenberger).

A. Noyau urbain :

I. Zones construites avant 1840 (vieille ville, faubourgs, banlieue) : 1. Zones résidentielles dominantes. — 2. Quartiers avec industries en arrière-cours. — 3. Faubourgs sur routes de sorties.

II. Zones construites entre 1840 et 1918 : 4. Zones résidentielles dominantes. — 5. Quartiers avec établissements industriels. — 6. Pointes d'accroissement d'aspects variés.

III. Période de l'entre deux guerres et d'après-guerre : 7. *Zones d'accroissement marginal et* utilisation des espaces vides. — 8. Limite entre le noyau urbain à habitat serré et la zone périphérique lâche.

B. Éléments distincts :

9. Structure de « city ». — 10. Principales artères commerçantes. — 11. Établissements industriels. — 12. Gares et voies ferrées. — 13. Complexes publics. — 14. Espaces verts.

C. Zone périphérique :

15. Zones résidentielles. — 16. Zones de transition (Schrebergarten, habitations provisoires, etc.). — 17. Cimetières. — 18. Terrains vagues. — 19. Vignobles. — 20. Autres surfaces cultivées

Fig. 2 L'extension de Vienne

Le Groupe des "Sages" (1972), constitué par le gouvernement français pour projeter l'économie française à l'horizon 1985, a notamment signalé que "le monde urbain français croîtrait jusqu'à former le 4/5 de la population et que, petites ou grandes, les villes doubleraient au cours d'une période de 13 ans (1972-1985)". Ceci, exprimé en consommation d'espace, est souvent enregistré sur des terres agricoles de fertilité notable du fait du site des principales agglomérations françaises.

Il a été également constaté que Montpellier, célèbre par son urbanisme lâche, a augmenté de 37% en espace entre deux recensements (10 ans).

Au Japon, la surface comprise à l'intérieur des limites urbaines équivaut au cinquième du total des surfaces de cultures qui subissent actuellement de plus en plus de pression et perdent chaque année des proportions importantes.

Il est vrai qu'il s'agit là de petits territoires: aux Etats-Unis, en 1950, les 157 complexes urbains de villes de plus de 50 000 habitants ne couvraient que 1% de la surface totale du pays; mais actuellement le nombre de ces villes a beaucoup augmenté et la superficie construite s'est multipliée par 2,5 environ. En effet, les villes américaines se caractérisent par leur grand étalement, ce qui fait qu'elles accaparent beaucoup d'espace et de ce fait endommagent beaucoup de terres agricoles puisqu'elles hypothèquent des superficies importantes qu'elles enlèvent à l'agriculture sans les exploiter par les utilisations non agricoles. Ainsi, en Californie où on enregistre les records dans ce domaine, la ville de Sanjosé Santa Clara renferme 86% de terrains non encore employés hypothéqués par les constructions, San Francisco en renferme 75%, Los Angeles 65%.

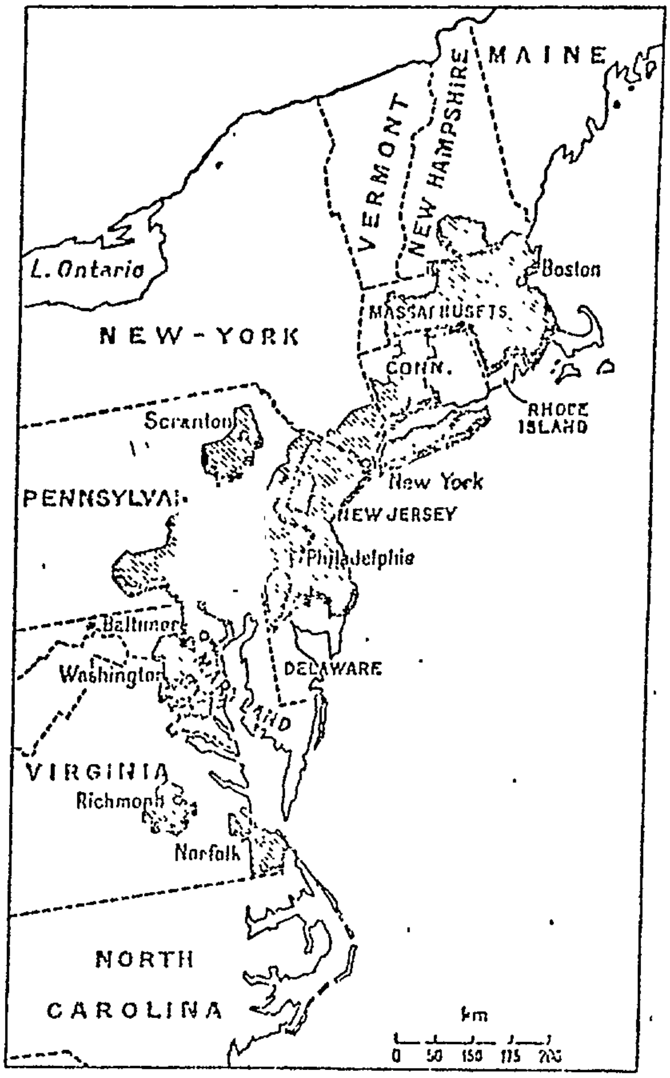
Cette dernière ville a connu une extension démesurée aux dépens de terres agricoles fertiles très productives. En effet l'aire urbaine de cette ville est passée de 67,2 km^2 en 1850 à 1088,16 km^2 en 1950 et à plus de 1200 km^2 actuellement. Encore 2 millions de personnes environ vivent en dehors des limites de la ville alors qu'il existe, à l'intérieur de ces limites, plusieurs enclaves réfractaires.

Sur la côte atlantique, il y a plus de 100 km de Philadelphie à New-York, 250 de Boston à New-York; mais toute une chaîne de villes les relie dont plusieurs ont plus de 100 000 habitants.

Et ainsi, par extension et étalement, ces villes sont devenues coalescentes donnant lieu à un ensemble urbanisé de plus de 55 millions d'habitants que Jean Gottman a baptisé "Mégalopolis". Les villes des Mégalopolis se rapprochent au fil des années et tout l'espace qui les sépare a été urbanisé (Fig. 3).

Aux Indes, les problèmes d'extension urbaine aux dépens des terres agricoles sont également atrocement ressentis. En effet, la ville de Haiderabad est passée de 51,8 km^2 au milieu du XIXème siècle à 215,2 km^2 en 1951 et à plus de 350 km^2 actuellement, soit une augmentation de 7 fois.

VILLES VOISINES ET CONURBATIONS



(D'après Jean GOTTMANN, « Megalopolis or the Urbanisation of the Northeastern Seabord », *Econ. Geography*,

Fig. 3 Megalopolis

Vu l'importance du phénomène, le conseil indien pour la recherche agricole (I.C.A.R.) s'est penché sur la question et a signalé dans son rapport en 1981 que la zone urbaine de la ville de New Dehli est passée en une période de 80 ans (1901-1981) de 43,3 km^2 à 660 km^2, soit une augmentation de 15 fois. Le rapport estime également qu'en l'espace de 20 ans (1951-1971) la superficie agricole utile de la région de New Delhi est passée de 94 000 hectares à 78 000 hectares. Ainsi 16 000 hectares ont été cédés à la ville selon un grignotage moyen de 800 ha/an.

Pour le cas de la Chine, on estime qu'en 20 ans (1957-1977) 33 millions d'hectares de terres agricoles ont été perdus, soit un peu moins de 30% de la surface agricole utile. Au cours de cette période, le développement urbain et le boom industriel ont absorbé à eux seuls 20% de cette perte, soit environ 6,6 millions d'hectares.

Tous ces exemples pris à travers différents pays dans le monde illustrent clairement l'ampleur du problème et traduisent nettement l'acuité du conflit entre les utilisations agricoles et les utilisations non agricoles des terres. Partout, l'agriculture bat en retraite.

3.2 La dimension du problème dans le monde méditerranéen

Spécificité et ampleur:

Tous les pays méditerranéens, sans exception, enregistrent avec acuité l'ampleur du conflit entre les affectations des terres. Partout les terres de culture subissent une agression quotidienne suite aux extensions inconsidérées de l'urbanisation, des installations industrielles et touristiques, des infrastructures de communication et d'équipement, des installations d'extraction minière, etc. L'effort déployé par les pays méditerranéens depuis quelques décennies pour la promotion des secteurs économiques secondaires et tertiaires a été à l'origine de l'essor que connaissent les affectations non agricoles des terres. Le relatif délaissement du secteur agricole, délibéré ou non selon les pays, enregistré durant les dernières décennies, a favorisé le phénomène de la perte des terres agricoles au profit des utilisations non agricoles: les villes devenues les moteurs du développement économique et social, connaissent d'une part une explosion démographique due en grande partie à l'exode rural qui prive les campagnes de leurs forces de travail dynamiques (exode des jeunes) et d'autre part une extension inconsidérée en grignotant des espaces importants sur les campagnes environnantes. Le bilan se traduit par une perte en terres agricoles.

Cette perte a été estimée pour le cas de la ville du Caire à environ 3 500 hectares en dix ans (1968-1977), et le chiffre moyen de cette perte enregistré annuellement depuis les années 80 est de 500 hectares.

Ce phénomène est remarquable pour toutes les villes, même celles qui sont de création récente. Si on ne dispose pas de chiffres sur les superficies perdues par urbanisation, on peut percevoir l'ampleur de ce phénomène grâce aux chiffres d'augmentation de la population.

A Istamboul, en Turquie, en 4 ans (1971-1975), le noyau ancien de la ville a enregistré une augmentation de 285 000 habitants tandis que les faubourgs et les banlieues ont augmenté de 1.800.000 habitants.

La proportion des populations urbaines a enregistré partout une augmentation importante. En Tunisie, elle est passée de 45% au début des années soixante à presque 65% actuellement.

Ainsi les villes se surpeuplent; leur taux d'accroissement démographique est plus important que le taux moyen pour l'ensemble du pays. Athènes, par exemple, a connu entre 1961 et 1977 un taux d'accroissement démographique de 3,5% alors que ce taux n'a pas excédé 0,55% pour l'ensemble de la Grèce. La population de Tripolis s'est accrue de 13% tandis que l'ensemble de la Libye n'a enregistré qu'un taux d'accroissement démographique de 4% seulement.

Pour l'ensemble des pays méditerranéens, on estime qu'il y a environ 8 millions d'habitants sur la rive Sud et 17 millions sur la rive Nord qui se concentrent dans 17 villes côtières de 700.000 à 4 millions d'habitants chacune.

Athènes, par exemple, regroupe plus du tiers de la population totale grecque, concentre 46% des activités industrielles du pays, 49% des fonctions du secteur de l'énergie et 42% du commerce de détail.

Alexandrie, avec ses 2,5 millions d'habitants forme la ville portuaire la plus grande du sud de la Méditerranée. Elle assure plus de 90% du commerce maritime égyptien et regroupe une part importante du secteur touristique et industriel.

La dynamique économique et démographique de ces villes se traduit spatialement par une extension démesurée. Celle-ci est dangereuse sur le secteur agricole pour les raisons suivantes:

- A l'origine, la majorité des villes méditerranéennes étaient des agglomérations rurales, elles vivaient et se développaient grâce aux activités agricoles principalement, commerciales et artisanales ensuite. L'importance de l'agriculture était manifeste même pour les villes issues des anciens comptoirs commerciaux. C'est le cas des villes de Sfax, Alexandrie, Tripolis, Alger, Tunis, Nice, Marseille, etc... La fertilité des terres était le critère le plus déterminant dans le choix de l'emplacement de l'agglomération au début de sa constitution pendant les périodes anciennes.

Ainsi, la majorité des villes méditerranéennes se localisent dans des régions au sol fertile, généralement les plaines. Or les conditions topographiques et géomorphologiques ont fait que la majorité des plaines vastes et fertiles constituent les zones littorales de la Méditerranée. Les principales villes et les plus grandes dans les différents pays méditerranéens se localisent dans la frange littorale (Fig. 4). Ainsi, l'extension de ces villes engendre inévitablement une perte des terres agricoles.

- La superficie des terres agricolement fertiles pour l'ensemble des pays méditerranéens est relativement faible; elle ne représente que 28% de la superficie totale de ces pays (846 millions d'ha), soit 240 millions d'hectares seulement. Le reste est constitué de terres incultivables, arides et désertiques.

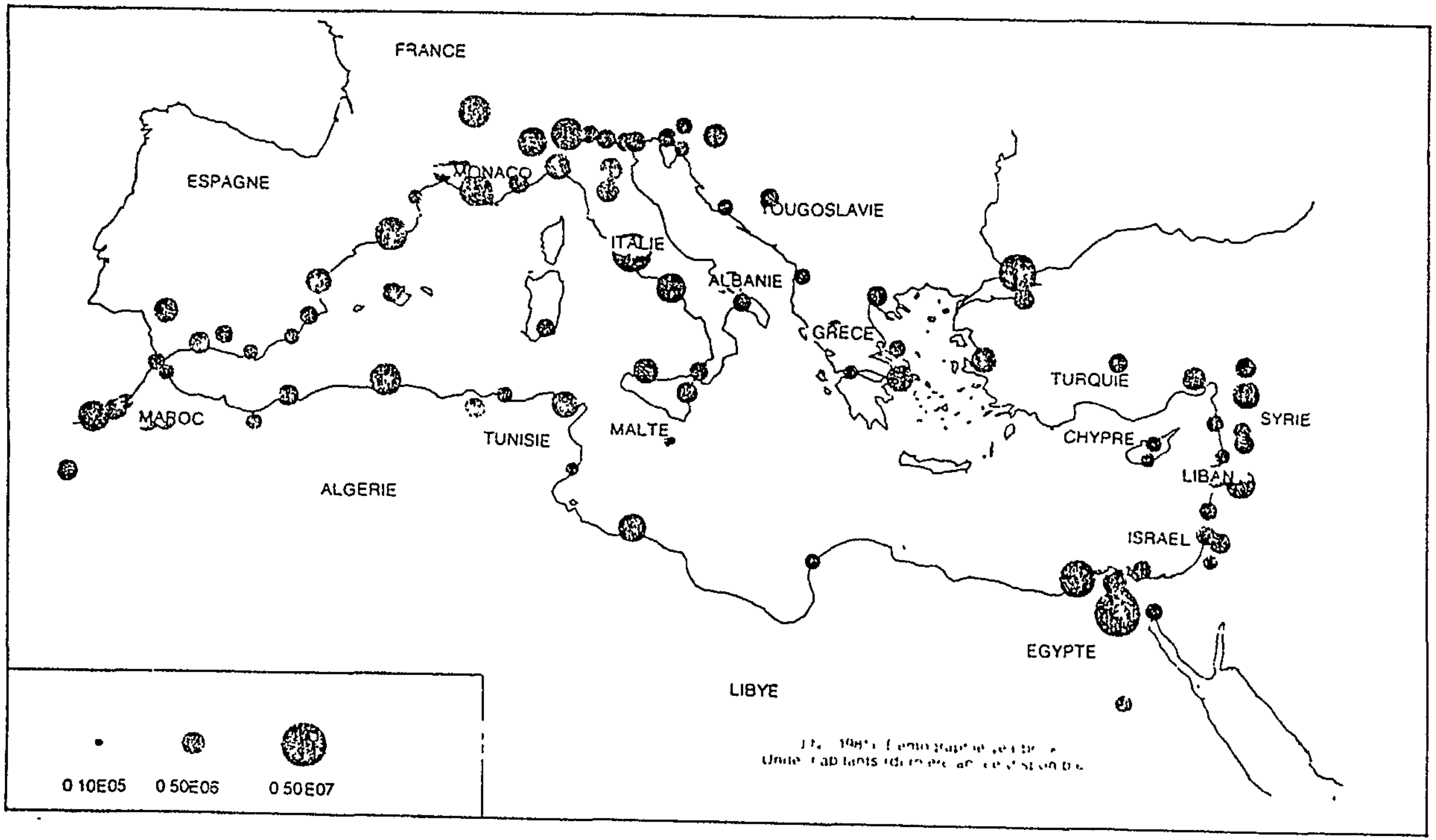


Fig.4 Principales villes méditerranéennes

D'autre part, les terres utiles à l'agriculture subissent de plus en plus les effets des processus d'érosion de désertification et de dégradation physiques, chimiques et biologiques activés par les caprices du climat, la fragilité des écosystèmes naturels et la mauvaise gestion des ressources par l'homme. L'érosion hydrique et éolienne entraîne la perte d'environ 100.000 à 200.000 hectares de terres agricoles par an dans les pays du Magreb. A ce train, vers la fin du siècle, les pays du Maghreb auraient perdu environ 2 millions d'hectares de terres agricoles soit 12% de la superficie agricole totale.

Si à cette perte, à laquelle il est difficile et très coûteux de faire face, s'ajoutent les pertes causées par l'extension irréfléchie des utilisations non agricoles, la situation des pays méditerranéens devient dangereuse puisqu'ils ne peuvent plus assurer leur autosuffisance alimentaire ou ne pourraient plus la réaliser; leur dépendance économique et par voie de conséquence,politique vis-à-vis des grandes puissances se renforce, ce qui entraîne un déséquilibre économique et social flagrant qui ne permet pas de faire fructifier les efforts de développement déployés; ceci est surtout valable pour les pays de la rive sud de la Méditerranée dont l'exiguité des terres agricoles fertiles est plus marquée. Pour tous ces pays, les sols constituent une ressource naturelle non renouvelable; ces sols sont hérités de périodes climatiques moins arides et ne peuvent plus se constituer sous les conditions actuelles. Ainsi la perte d'un m^2 de ces sols constitue une perte irremplaçable; et chaque hectare de perdu par érosion, désertification ou en raison des constructions nuit à jamais au potentiel de production agricole.

Ainsi, pour les pays méditerranéens, la perte des terres agricoles par les utilisations non agricoles revêt des dimensions inquiétantes et fait peser une menace sur l'avenir de ces pays. Elle engendre un problème complexe qui dépasse les simples considérations d'aménagement de territoire comme c'est le cas des pays d'Europe atlantique, pour revêtir un caractère civilisationnel: la majorité des pays du sud de la Méditerranée dont la vie économique et sociale est encore conditionnée par l'agriculture, ne peuvent jamais assurer un avenir civilisationnel stable et équilibré s'ils continuent à perdre aussi facilement leur sol fertile, c'est-à-dire le support de leur système socio-économique.

L'ampleur du problème causé par les extensions inconsidérées des utilisations non agricoles sur la production agricole est plus grave encore si on prend en compte les effets négatifs de certaines utilisations industrielles et minières sur l'environnement rural. Ces utilisations constituent des sources de pollution qui peuvent endommager la production agricole en des proportions plus grandes que le simple grignotage des terres fertiles. L'arrière-pays des principales villes industrielles méditerranéennes en est un exemple vivant: l'arrière-pays de l'étang de Berre, la Mitidja algéroise, l'arrière-pays sfaxien, l'oasis de Gabès, etc.

Ainsi, comparativement à d'autres régions dans le monde, le problème de la perte des terres agricoles par les utilisations non agricoles revêt, dans les pays méditerranéens, une singularité qui lui confère une dimension civilisationnelle. L'ampleur de ce problème dans les zones côtières tunisiennes, illustre bien cette singularité.

4. LES ZONES DE LA COTE ORIENTALE TUNISIENNE ET LEUR PREDISPOSITION A L'AMPLIFICATION DU PHENOMENE

Le phénomène d'extension des utilisations non agricoles aux dépens des terres agricoles est bien marqué dans l'ensemble du pays. Cependant il acquiert des dimensions alarmantes surtout dans les zones littorales et notamment sur la côte orientale qui abrite les plus grandes villes du pays: Tunis, Nabeul-Hammamet, Sousse-Monastir, Sfax et Gabès. L'objet de ce rapport est d'analyser ce phénomène en évaluant son ampleur et les tendances de son évolution.

4.1 Conditions naturelles de la côte orientale

Les conditions naturelles des côtes orientales du pays sont très bien analysées dans le rapport national tunisien relatif à la "Promotion de la protection du sol" (1). Une synthèse de ce rapport montre que, par rapport à l'ensemble du territoire, la côte orientale tunisienne se caractérise par l'aisance de son relief, la douceur de son climat et la fertilité de son sol.

En effet, la majorité du territoire de la zone étudiée est constituée de plaines vastes et relativement fertiles. C'est le cas notamment du delta de la Medjerdha qui compose le Nord-Est du pays.

Au nord de cette plaine, la région de Bizerte est constituée de petites plaines très fertiles intercalées entre des collines très peu élevées. C'est le même paysage qui caractérise le sud du District de Tunis, le Cap-Bon et le Sahel de Sousse-Monastir. Au sud de cette ville, s'étend une vaste plaine sous-tendant le golfe de Gabès et se relayant par la plaine d'El Aradh (arrière-pays de Gabès), la plaine de la Jeffara.

L'ensemble de ces plaines et collines est constitué de sols relativement fertiles. Ces derniers sont soit des sols alluviaux riches en matière organique et à texture moyenne à fine (plaine de Medjerda) soit des sols évolués isohumiques ou calcimagnésiques (Cap-Bon, Sahel, arrière pays sfaxien et Jeffara).

D'autre part, étant ouvert sur le bassin oriental de la Méditerranée, cette côte jouit de températures modérées et d'humidité presque permanente tout au long de l'année. En effet, il est rare que les températures minimales descendent au-dessous de zéro, même pendant la saison hivernale. Pendant l'été, une chaleur excessive n'est que rarement enregistrée (passage du vent chaud "le Sirocco"). Le manque de pluie (2), et sa mauvaise répartition sont relativement corrigés par l'abondance de la rosée, ce qui procure à cette côte une humidité acceptable. En effet, pour la région sfaxienne qui ne reçoit que 200 mm de pluie par an seulement, l'apport d'humidité provenant de la rosée et de la brume est équivalent à 100 mm de pluie.

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(1) Promotion de la protection du sol comme composant essentiel de la protection de l'environnement des zones côtières méditerranéennes "Rapport National tunisien - Split - 1985, Ahmed Souissi.

(2) Au nord de la zone d'étude, les pluies varient autour de 450 mm, elles sont de 350 mm au centre et tombent à moins de 250 au sud.

Ainsi favorisées par toutes ces conditions naturelles propices, les zones de la côte orientale ont constitué depuis l'antiquité un foyer de civilisation très actif.

4.2 Les conditions historiques et socio-économiques de la côte orientale

Depuis l'antiquité, les Grecs, les Phéniciens et surtout les Romains ont favorisé le peuplement de la côte orientale de la Tunisie par les comptoirs commerciaux qu'ils y ont implantés. Certains de ces comptoirs, qui n'avaient pas au début un contact important avec l'arrière-pays, se sont développés et ont pu rayonner sur l'ensemble du territoire de l'"Ifriquia". L'essor de ces comptoirs, tels Carthage (Tunis), Hdrumète (Sousse), Napolis (Nabeul), Sifax (Sfax) a débuté quand ils ont pu joindre à l'activité commerciale et d'échange avec les villes méditerranéennes, l'activité agricole, et ce en créant et organisant des campagnes autour d'eux. Ce sont les Romains, à civilisation paysanne et citadine, qui furent à l'origine de l'organisation de campagnes riches autour des anciens comptoirs. Les conditions naturelles ont bien favorisé cette mise en valeur agricole, ce qui explique son extension sur l'ensemble de la zone.

Les conquêtes arabo-islamiques ont permis d'accentuer davantage la mise en valeur des campagnes autour des villes. Ceci a été remarquable notamment durant les périodes fatimide Hafside et Hussénite qui ont favorisé l'essor de toutes les villes littorales.

Ainsi, depuis ces périodes, les campagnes littorales n'ont cessé de s'organiser et de s'étendre à partir de leur point de départ qui était la ville.

Les invasions dévastatrices qui ont eu lieu durant le moyen-âge par les Vandales, Berbères et Normands n'ont que très peu désorganisé ces campagnes.

L'activité agricole est restée, au fil des siècles, l'activité de base pour l'ensemble de la zone côtière malgré l'importance des villes qui la contrôlaient. L'extension de ces dernières était insignifiante.

En effet, les utilisations non agricoles des terres n'ont que très peu dépassé les limites anciennes de ces villes. Les premières "cités" extra-muros n'ont apparu qu'entre les deux guerres, et ont commencé à s'étendre aux dépens des terres agricoles. La campagne péri-urbaine, relativement organisée et caractérisée par des types d'occupation humaine et d'habitat isolés spécifiques commence à être agressée par le bâti. Ce phénomène s'est amplifié depuis les années cinquante par l'activation de l'exode rural dû aux mutations sociales et économiques qu'a connues le pays, et notamment les campagnes.

En effet, depuis l'indépendance (1956), la Tunisie a connu un développement socio-économique marqué par un déséquilibre entre l'intérieur et la zone côtière. Celle-ci, déjà favorisée historiquement, a drainé la majorité des efforts de développement consentis par la Nation. C'est ainsi qu'elle abrite actuellement plus de 63% des habitants, accapare 80% de l'emploi industriel (Fig. 5) et la majorité des infrastructures industrielles (Figs. 6 et 7), et détient environ 90% de l'équipement et de la capacité touristiques (Fig. 8).

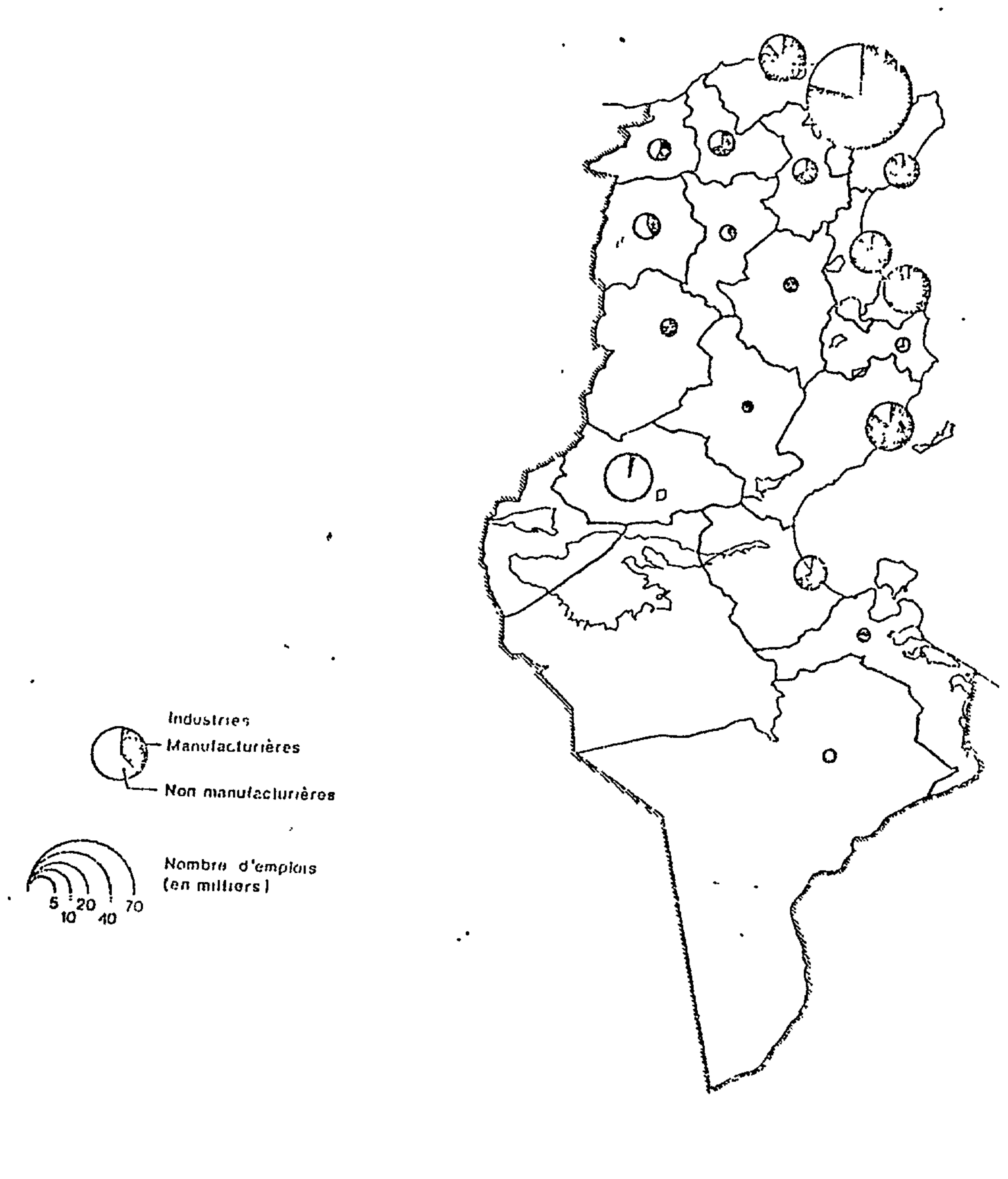

Fig. 5 Emplois industriels, 1980

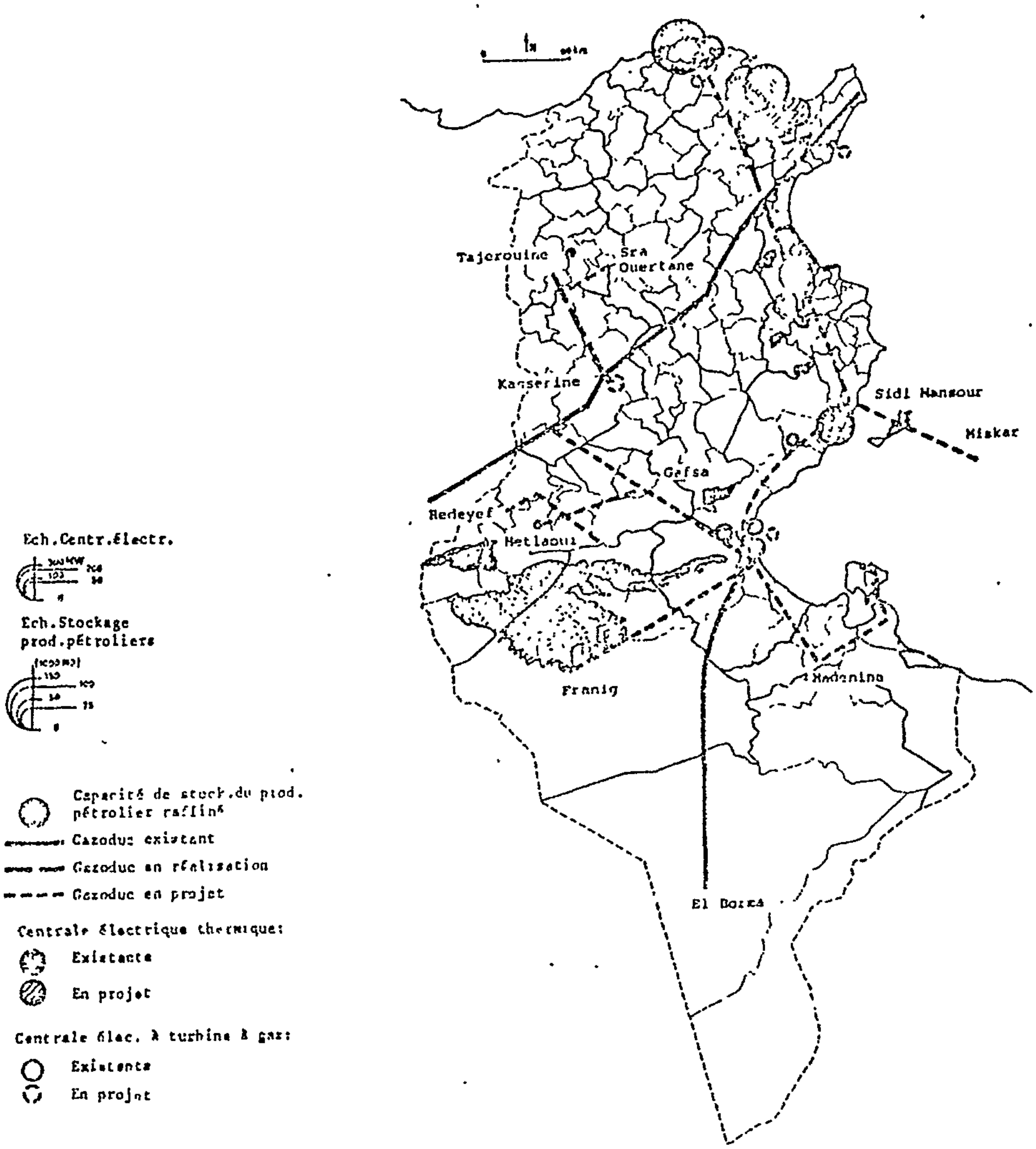

Fig. 6 Hydrocarbures et énergie

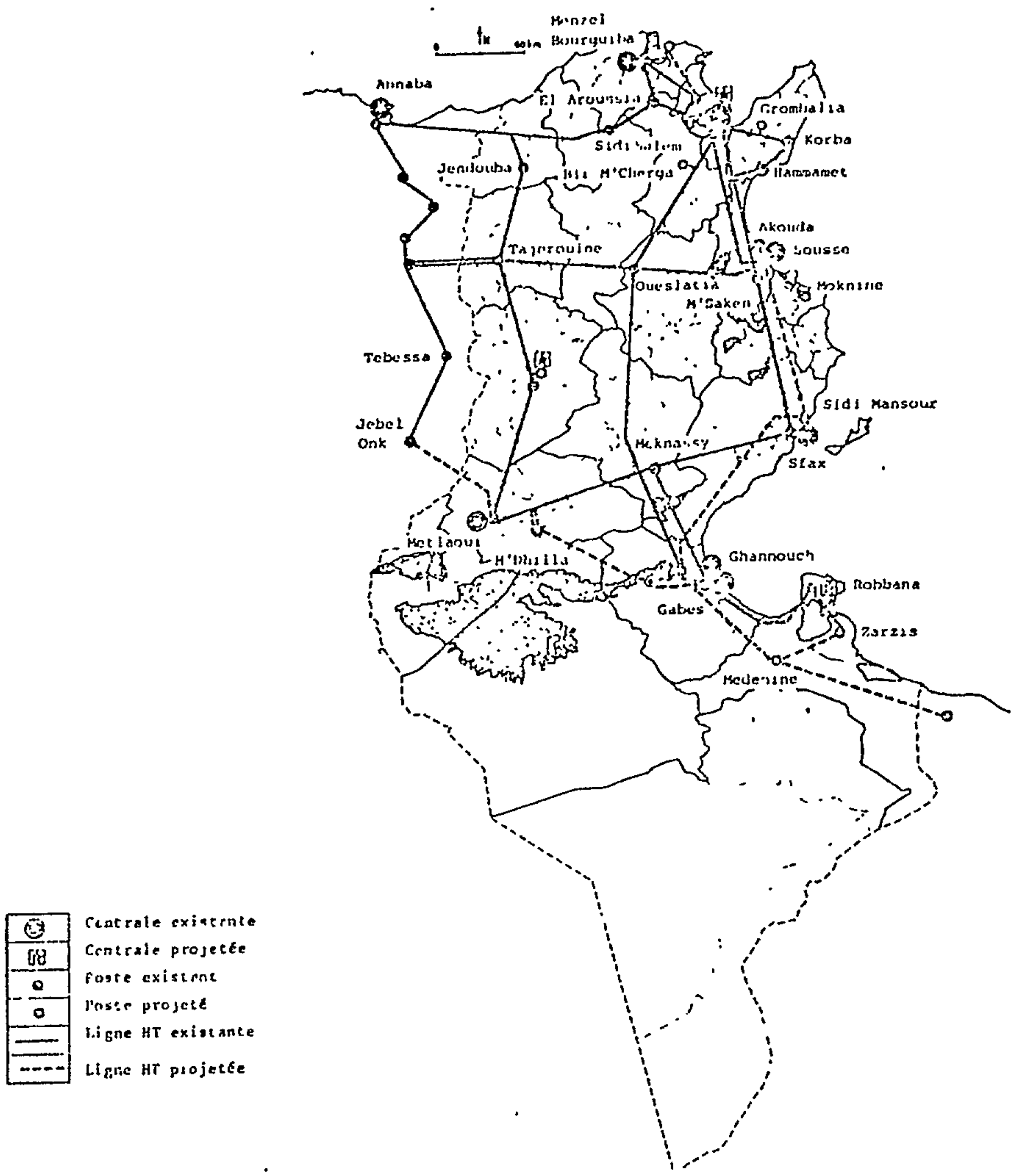

Fig. 7 Schéma du réseau électrique haute tension

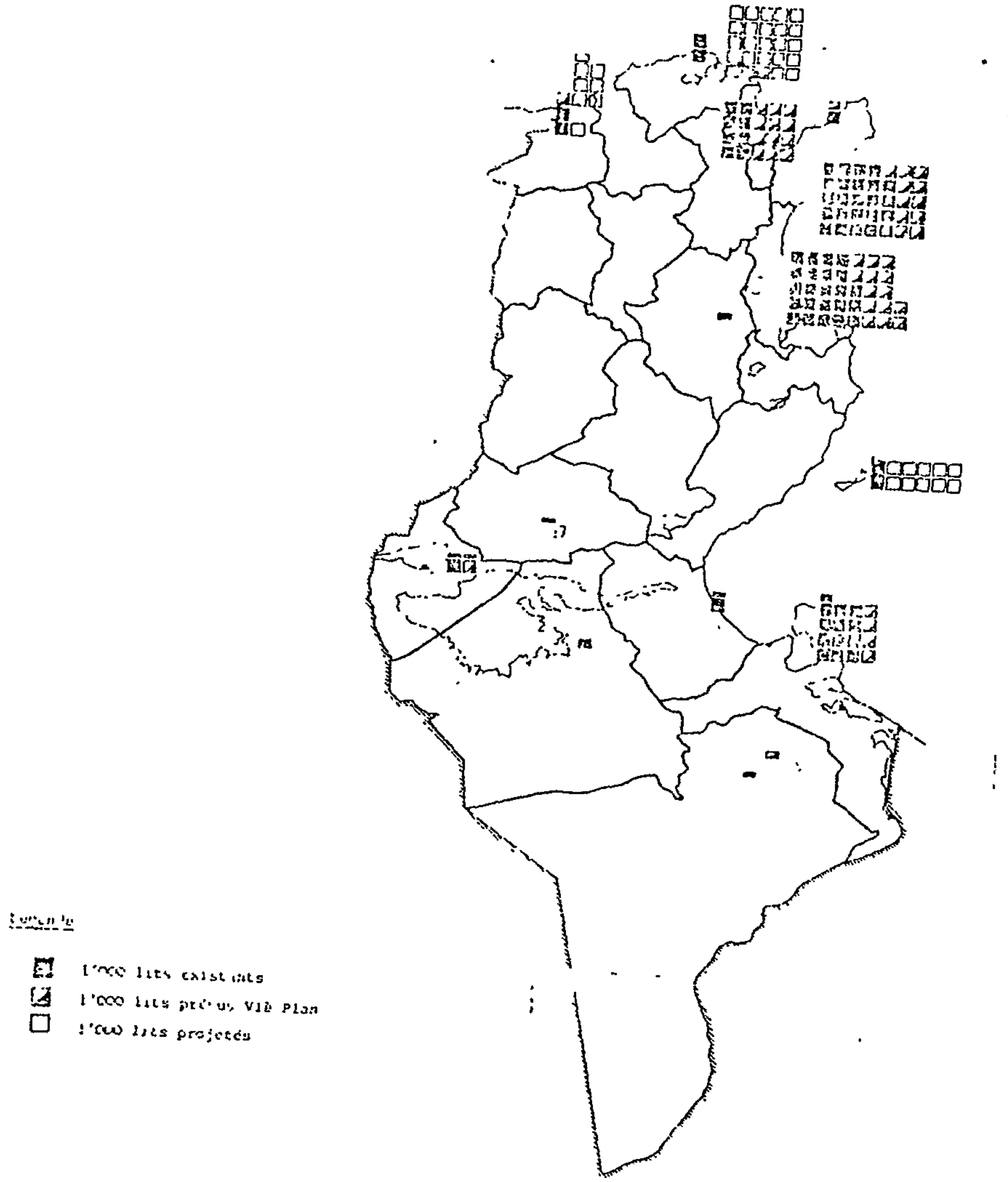

Fig. 8 Equipement hôtelier - capacité actuelle et projetée

D'autre part, avec 900.000 ha, elle occupe le tiers des terres fertiles du pays évaluées à environ 2,7 millions d'ha. Ces terres sont les plus productives et les mieux organisées (Fig. 9).

Ces terres sont actuellement en prise directe avec le développement accéléré des villes marquées par l'extension du bâti en dehors des limites traditionnelles, par la prolifération des installations industrielles, touristiques et par la multiplication des carrières aux pourtours des agglomérations.

Ainsi, en plus des problèmes que causent les processus d'érosion et de dégradation qui ne sont que par endroit très actifs, les terres agricoles subissent la poussée du phénomène urbain, et voient leur superficie se réduire au fil des années, et leur rendement diminuer suite à l'exode rural.

Devant l'ampleur de ce problème, les pouvoirs publics ont pris depuis les années soixante-dix un certain nombre de mesures pour protéger les terres agricoles autour des villes.

4.3 Les mesures de protection des campagnes péri-urbaines

Les terres agricoles, dans la zone côtière orientale, ont fait l'objet de plusieurs mesures réglementaires et législatives ainsi que d'actions directes tendant à les sauvegarder, les protéger et les conserver.

Leur conservation et protection contre les processus d'érosion, de désertification et de dégradation chimique et biologique ont été depuis longtemps réglementées par le code forestier ou par des décrets spécifiques obligeant le labour selon les courbes de niveau et encourageant la réalisation des aménagements anti-érosifs dans les exploitations agricoles. Plusieurs bassins versants côtiers ont fait l'objet de projet de conservation des eaux et du sol réalisés par les autorités et les populations.

Ces efforts continuent de s'étendre sur tous les secteurs sensibles à l'érosion et à la désertification.

Cependant, à côté de ces mesures et actions, les pouvoirs publics ont mis en place d'autres dispositifs pour limiter l'extension anarchique de l'urbanisation aux dépens des terres agricoles. La promulgation du code de l'urbanisme survenue au début des années soixante-dix a permis de rationaliser l'urbanisation.

L'effort d'application de ce code a été porté au début pour les principales villes du pays qui se concentrent toutes dans notre zone d'étude, à savoir la côte orientale. Ainsi, toutes ces villes ont fait l'objet d'un plan directeur d'urbanisme (P.D.U.) qui planifie leur extension et l'allocation de l'espace environnant jusqu'à la fin du siècle.

Ces P.D.U. ont été renforcés par des plans d'aménagement qui détaillent à un haut niveau de prévision l'affectation des terres urbaines et péri-urbaines.

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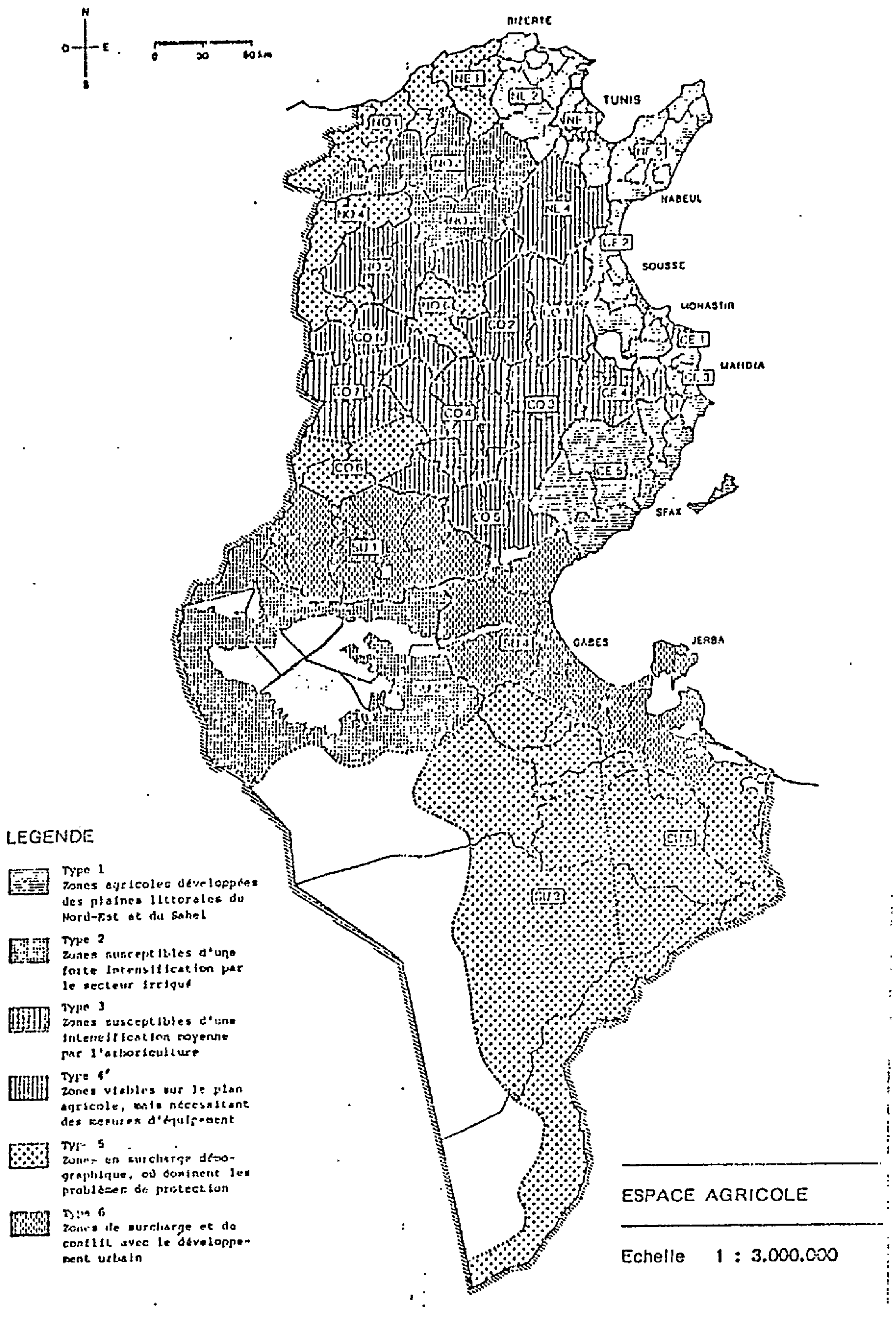

Fig. 9 Schéma national d'aménagement du territoire

Un souci de protection des terres agricoles imprègne manifestement le code de l'urbanisme. Mais ce souci n'est pas souvent respecté par les aménagistes dont la majorité, étant des architectes, sont omnubilés par les considérations de coût de l'urbanisme, de rentabilité des infrastructures et des équipements collectifs, etc. et ont été insensibles à la sauvegarde des terres agricoles fertiles. C'est ainsi que l'extension de certains quartiers de la ville de Tunis a été orientée sur les terres fertiles de l'office des périmètres irrigués de Mejerda. Des terres occupées par une arboriculture fruitière en pleine production furent allouées à l'urbanisation dans le cadre du plan d'aménagement de la ville de Bizerte. Il en va de même pour les villes de Nabeulet Hammamet où les plans d'aménagement touristique ont accaparé des centaines d'hectares de vergers.

En plus de ces facteurs, le non respect des plans d'aménagement par les promoteurs immobiliers et la population a fait que d'autres espaces agricoles en production sont perdus sous le bâti. L'exemple du territoire du "District de Tunis" est bien évocateur à ce sujet. En effet, entre 1975 et 1983, 1636 hectares de terres ont été accaparés par les utilisations non agricoles dans ce territoire, dont 671 hectares par l'habitat non contrôlé par les plans d'aménagement, c'est-à-dire l'habitat anarchique.

Ce phénomène se répète pour toutes les villes tunisiennes, mais à des degrés différents.

C'est ainsi que devant l'amplification de ce phénomène, et contraint par des considérations d'auto-suffisance alimentaire, le Gouvernement tunisien a promulgué la loi (1) de protection des terres agricoles contre les utilisations non agricoles.

Cette loi renforce les mesures du code de l'urbanisme par un ensemble de décrets (2) qui règlementent et orientent les utilisations non agricoles afin que celles-ci ne portent pas préjudice à l'activité agricole que ce soit par les retombées de pollution ou par le grignotage des terres fertiles. L'analyse de quelques cas concrets va permettre de dimensionner l'ampleur de la perte des terres agricoles par les utilisations non agricoles et les corrections apportées ou programmées pour lutter contre ce phénomène en Tunisie.

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(1) C'est la loi 83 - 87 du 11 novembre 1983.

(2) Des décrets relatifs aux modalités de changement de vocation des terres de sauvegarde et soumise à autorisation.
- un décret relatif à la révision des périmètres publics irrigués
- un arrêté réglementant les constructions dans les exploitations agricoles.

5. *DIMENSION ET AMPLEUR DES PROBLEMES DE LA PERTE DE TERRES AGRICOLES* PAR LES UTILISATIONS NON AGRICOLES

5.1 L'ampleur du phénomène sur la côte orientale

Sur un total de 16 millions d'hectares, la Tunisie ne dispose que de 5 millions d'hectares de terres agricoles utiles, soit 18% seulement dont environ 2,8 millions d'hectares de terres fertiles. La côte orientale détient à elle seule 900.000 hectares de ces terres, soit le 1/3 du potentiel national en terres fertiles.

D'autre part, cette côte orientale abrite les villes les plus dynamiques et les plus peuplées du pays. Ces villes n'ont cessé de s'accroître durant les trois dernières décennies, ce qui a entraîné un grignotage de ces terres fertiles. L'exemple de la ville de Tunis qui était séparée de ses banlieues par une campagne riche et prospère jusqu'aux années cinquante est spectaculaire à cet égard.

En effet, par le dynamisme économique dont cette ville a fait preuve depuis l'Indépendance, l'effectif de ses habitants a augmenté très vite ce qui a entraîné l'étalement des faubourgs dans le sens des principales banlieues. Ces dernières, évoluant au début comme cités-dortoirs pour la ville de Tunis, se sont très vite érigées en véritables villes très dynamiques et prospères à économie intégrée où services, commerces et industries offrent un volume d'emploi important que l'exode rural et également l'exode à partir des autres villes de l'intérieur comblent en partie. Ces nouvelles villes, telles l'Ariana, le Bardo, Hammam-lif - Ben Arous, Rades, Ezzahra, la Marsa, Carthage, etc. se sont très vite étendues au dépens des campagnes qui les séparaient de la ville de Tunis. Actuellement, on assiste à un tissu urbain continu qui joint cette ville avec ses anciennes banlieues et certaines de ces dernières entre elles, telles Hammam-lif, Ezzahra, Rades pour le secteur sud, Carthage, la Marsa, l'Ariana et le Bardo pour les secteurs Est et Nord - Nord-ouest.

Le District de Tunis, bureau d'étude chargé de planifier et contrôler l'extension de cette grande agglomération naissante, a estimé à environ 1636 hectares les superficies bâties entre 1975 et 1982 sur l'ensemble du territoire contrôlé par la ville de Tunis et ses banlieues, soit 234 hectares de terres agricoles productives de perdus chaque année en moyenne durant 7 ans. Ce chiffre s'est amplifié ces trois dernières années. Le taux d'urbanisation de la partie sud de ce territoire qui était de 6% en 1962 est actuellement de 34%. Ce phénomène est également observé pour toutes les autres villes de la côte orientale. Les villes de Hammamet et de Nabeul, par l'essor du tourisme, ont vu leur périmètre urbanisé passer respectivement de 47 ha et 67 ha en 1947, à 730 ha et 750 ha en 1974, soit une perte totale de 1366 ha de terres agricoles riches qui jouaient un rôle déterminant dans l'approvisionnement quotidien des marchés de ces villes en produits maraîchers et fruitiers. En plus les campagnes riches qui séparaient ces deux villes ont perdu environ 1000 ha entre 1975 et 1982 par l'extension des installations touristiques. Les villes de Sousse, Monastir et Gabès dans la zone ont également enregistré les mêmes tendances. En effet, cette dernière, de 228 ha seulement en 1948, au centre d'une oasis parmi les plus importantes du pays, a vu son périmètre bâti passer à 1330 ha en 1974, occasionnant la perte d'environ 1100 ha de terres dont la majorité étaient des terres irriguées à haut potentiel.

La ville de Sfax, seconde grande ville du pays avec environ 350 000 habitants, s'est étendue entre 1962 et 1982 d'environ 6 000 ha sur les vergers très productifs qui constituent son arrière-pays direct. En effet, cette ville se compose d'un noyau urbain ancien, la Médina, entouré de remparts et cotoyé par des faubourgs immédiats; la Médina et ses faubourgs s'étendent sur 236 ha. Cet ensemble urbain est entouré sur un rayon de 7 km environ d'un espace agricole typique, les "Jnén", qui sont des jardins à arbres fruitiers et à culture maraîchère, seuls fournisseurs des marchés ou "Souks" de la ville en produits agricoles de consommation quotidienne. La majorité de ces "Jnén" qui s'étendaient sur 12.000 hectares autour de la ville, étaient jalonnés de maisons isolées qui constituaient le logement estival d'une bonne partie des habitants de la Médina.

L'extension urbaine qu'a connue cette ville a été due à la densification du bâti dans les auréoles de "Jnén". Jusqu'en 1962, les Jnén qui ceinturent les faubourgs sont presque complètement urbanisés en plus de la constitution de petites cités-dortoirs localisées à la périphérie des Jnén, à environ 8 km du centre. L'ensemble des espaces urbains était à cette date de 1280 ha. A partir de cette date, on assiste à une densification du tissu urbain dans les différentes auréoles des "Jnéns". Ces dernières sont au nombre de 3. Les tableaux suivants illustrent l'emprise de l'urbanisation dans ces auréoles entre 1962 et 1982.

<u>Auréole I</u>: Comprise entre la rocade du Km 1 et le Km 4

Densification très poussée du tissu urbain durant la période 1962-1982

Année	Densité	Surface bâtie
1962	8,5 ares urbanisés / ha	263 ha
1982	80 ares urbanisés / ha	1.400 ha

Emprise de l'urbanisation: 1.137 ha

<u>Auréole II</u>: Entre rocade du Km 4 et Km 10

Année	Densité	Surface bâtie
1962	11,5 ares / ha	517 ha
1982	75 ares / ha	3.500 ha

Emprise de l'urbanisation: 3.000 ha

Auréole III: S'étend à l'extérieur de la rocade Km 10

Année	Densité	Surface bâtie
1962	8,5 ares / ha	305 ha
1982	60 ares / ha	2.118 ha

Emprise de l'urbanisation: 1.813 ha

Emprise totale de l'urbanisation dans le Grand Sfax
1.137 ha + 3.000 ha + 1.813 = 5.950 ha
Soit 300 ha / an

Ces différents exemples traduisent clairement l'ampleur du phénomène de perte des terres agricoles par les utilisations non agricoles sur la côte orientale de la Tunisie.

5.2 Les causes directes et indirectes du phénomène

L'essor économique qu'ont connu ces villes depuis l'Indépendance, notamment par le dynamisme du secteur tertiaire et de l'industrie, a drainé une population nombreuse venant des villes et campagnes de l'intérieur. Ceci a gonflé l'effectif des habitants des villes littorales, notamment Tunis, Sfax, Sousse, Monastir, Mahdia, Bizerte et Gabès. Sous le poids de l'explosion démographique et de la dynamique économique, ces villes ont été contraintes à s'étendre en dehors de leurs limites anciennes aux dépens de leurs propres campagnes. Les plaines, vu leur topographie commode et plane, ont été considérées comme les secteurs préférentiels d'extension urbaine puisqu'elles offrent le coût d'urbanisation le moins élevé. Or elles renferment les meilleurs sols et sous-tendent l'activité agricole la plus rentable. Mais devant la concurrence des autres secteurs économiques, notamment l'industrie et ses activités d'accompagnement, l'activité agricole perd de sa valeur et cesse d'être compétitive. Alors les anciens paysans, alléchés par les prix élevés que leur offrent les promoteurs immobiliers, industriels et touristiques pour l'acquisition de terrain en plaine ou sur glacis, ont favorisé l'extension des utilisations non agricoles sur les terres fertiles en cédant très vite leurs terres. Ce phénomène a été très actif, surtout depuis les années soixante-dix. Il s'agit là d'un système organisé de transactions foncières. Un autre système anarchique et illicite s'est également constitué permettant, parallèlement, aux masses importantes de ruraux en quête d'emplois plus rémunérateurs en ville, de s'entasser au voisinage de celle-ci dans des conditions très mauvaises en attendant que leur situation s'améliore. Aussi sont nées d'immenses cités sous-intégrées aux dépens des terres domaniales qui constituaient des campagnes très riches dont une partie est formée de périmètre irrigué.

On citera à titre d'exemple les cités Ettadhamen, Douar Hicher, Douar El Houch, Ezzouhour, Zahrouni, autour de l'agglomération tunisoise. L'accès facile à ces terrains domaniaux par des populations pauvres a été favorisé par tout un système de spéculation foncière orchestré par des gens qui ne sont pas propriétaires mais qui ont pu jouir de certains droits de mise en valeur sur ces terres domaniales. Alors, n'étant pas de vrais propriétaires, ces gens ont cédé facilement des lots de terrain de petite taille (70 à 100 m^2 seulement) à des prix relativement dérisoires par rapport aux prix des terrains destinés à la construction, mais nettement élevés comparés aux prix du terrain agricole. L'absence d'un contrôle foncier efficace des terres domaniales a favorisé beaucoup l'amplification de ce type de spéculation foncière.

Les facilités dont ont pu jouir les transactions foncières organisées ou inorganisées ont été les causes directes de l'extension anarchique des utilisations non agricoles aux dépens des campagnes riches périurbaines. C'est le cas pour la majorité des villes de la côte orientale de la Tunisie.

Cependant, les causes de l'emprise urbaine sur les terres agricoles à Sfax sont d'une autre nature. En effet, les citadins sfaxiens habitaient presque tous dans la Médina. Mais, vu l'essor démographique qu'a connu cette ville, la Médina n'a plus été en mesure de subvenir aux besoins en logements, ce qui a conduit les habitants à se satisfaire aux dépens des "Jnéns". Ainsi, on assiste à un morcellement progressif de ces derniers en petits lots variant de 500 m^2 à 1000 m^2 et plus. Le morcellement successoral dû à l'héritage a amplifié également l'emprise urbaine sur les jardins de Sfax. C'est ainsi que dans chaque jardin, qui a en moyenne 5000 m^2 de surface, à côté de la vieille maison, appelée "Bourj", du grand-père ou du père, chaque héritier construit sa villa individuelle dans un lot de 1000 m^2 en moyenne. Alors, d'une construction sur 5000 m^2 on arrive à 5 ou même 7 constructions sur cette même surface. Ceci s'est traduit par une nette dégradation de l'activité agricole dans les auréoles des "Jnen". La campagne périurbaine sfaxienne se transforme en un grand et vaste espace urbanisé difficilement contrôlé et à haut coût d'assainissement et d'équipement en infrastructures de base.

Le phénomène de "lotissement" des "Jnen" s'est amplifié encore quand le centre ville, c'est-à-dire la Médina, a perdu sa fonction résidentielle au profit des fonctions artisanales, commerciales et même industrielles. En effet depuis deux décennies environ, la majorité des citadins de la Médina, en quête de conditions de logement plus modernes, ont délaissé le centre de la ville pour habiter dans les Jnen en transformant leurs vieilles maisons de la Médina en ateliers, magasins ou même bureaux.

Le résultat de toutes ces évolutions sociales et économiques induites par un développement économique très dynamique est l'urbanisation de la riche campagne sfaxienne qui ne peut plus contribuer aujourd'hui à approvisionner les marchés quotidiens en produits agricoles de première nécessité.

Ainsi, la perte des terres agricoles par l'extension accélérée des utilisations non agricoles, remarquée dans la zone côtière orientale, s'est soldée par l'émergence de plusieurs problèmes écologiques, sociaux et économiques qui menacent sérieusement le cadre de vie des villes et surtout l'avenir agricole du pays.

5.3 Les retombées économiques, sociales et écologiques du phénomène de perte des terres agricoles

Il va sans dire qu'une extension inconsidérée des utilisations non agricoles des terres s'accompagne souvent de problèmes de dégradation de *l'environnement et de baisse des rendements dans les zones agricoles* agressées. Pour le cas de la côte orientale tunisienne, les retombées de ce phénomène sont d'ordre écologique, social et économique.

5.3.1 Les retombées écologiques

La mise en place d'unités industrielles polluantes à la limite du tissu urbain des agglomérations de Sfax et de Gabès s'est soldée par une destruction écologique des campagnes environnantes et par une nette dégradation du cadre de vie de ces deux villes.

En effet, la S.I.A.P. (1), implantée au sud-est de la ville de Sfax depuis *le début des années soixante, a entraîné la "désertification* écologique" d'un espace agricole sur plus de 10 km^2.

Il s'agit de la zone agricole très fertile de Aïon Fellat qui assurait, grâce à ses périmètres irrigués, 50 à 60% de la fourniture quotidienne des marchés de la ville en produits agricoles maraîchers et fruitiers.

Actuellement, par une stérilisation des horizons supérieurs du sol due à la concentration de polluants chimiques dégagés par l'usine, et par l'altération des eaux de la nappe également polluée, cette campagne riche et dynamique s'est transformée en l'espace de 20 ans en un vrai "désert" où rien ne pousse. On observe encore, au bord de la route G.P.1, quelques squelettes d'anciens arbres fruitiers complètement carbonisés présentant un paysage des plus désolés en Tunisie.

Le même phénomène est également observé dans les oasis du nord-ouest de la ville de Gabès détruites en partie par les pollutions engendrées par les Usines chimiques maghrébines traitant également les phosphates.

Un phénomène similaire est remarqué dans le territoire du District de Tunis, mais cette fois-ci dû à la prolifération des carrières de pierres et de sable au sein des campagnes.

En effet, la concentration de ces carrières dans des zones préférentielles a entraîné la détérioration de l'environnement agricole par les dégagements de poussière calcaire très nuisible pour les arbres fruitiers. Un net recul de l'activité agricole a été enregistré dans les campagnes environnant les secteurs de carrières.

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(1) S.I.A.P.: Société industrielle des acides phosphoriques: traitement des phosphates.

Ces trois exemples illustrent bien l'impact très négatif des utilisations non agricoles des terres sur les activités agricoles. L'espace est physiquement disponible, c'est-à-dire les terres existent encore, mais elles ne peuvent plus être exploitées à des fins agricoles. C'est un cas typique de désertification écologique des campagnes périurbaines par les utilisations non agricoles des terres. L'utilisation agricole bat en retraite devant le développement inconsidéré des utilisations non agricoles.

5.3.2 Les retombées sociales

L'extension inconsidérée des quartiers spontanés autour des villes aux dépens des campagnes productives a entraîné le délaissement de l'activité agricole dans certains secteurs.

En effet, les espaces agricoles compris entre ces quartiers spontanés sont hypothéqués par ces derniers qui ne leur permettent plus de jouer pleinement leur rôle; les propriétaires de ces terres fertiles ne peuvent plus exercer l'activité agricole vu les problèmes engendrés par le voisinage de ces quartiers surpeuplés et sous-intégrés (vol de la production, dommage fait aux arbres et aux cultures, non respect de l'exploitation agricole, etc.). Ainsi tous les espaces agricoles, constitués de terres fertiles et compris entre les cités spontanées de création nouvelle autour des villes, ont perdu leur vocation agricole. C'est une perte de terres agricoles fertiles. C'est le cas des secteurs de la Mannouba, Oued Ellil, Mnihla, Zahrouni, Chotrana, El Hraïria et tant d'autres pour le cas du district de Tunis. Les villes de *Sousse, Mahdia, Sfax et Bizerte connaissent également le même phénomène.* Le délaissement de l'activité agricole dans des terres fertiles est également amplifié par les spéculations foncières. En effet, les détenteurs des terres agricoles voisines du tissu urbain existant ne veulent plus investir dans l'agriculture et, laissant leur terre en friche, attendent une bonne offre pour la vendre aux utilisations non agricoles qui sont de loin plus payantes. Ce phénomène a constitué une cause directe du délaissement de l'activité agricole dans les campagnes périurbaines de la côte littorale.

Ainsi, dégradation de l'environnement et délaissement de l'activité agricole dus à l'extension des utilisations non agricoles des terres ont entraîné la perte de centaines d'hectares de terres agricoles nuisant ainsi au potentiel productif de la zone côtière orientale. L'économie de celle-ci est directement touchée.

5.3.3 Les retombées économiques

Les pertes de terres agricoles enregistrées dans la côte orientale, que ce soit par grignotage, par désertification écologique ou par délaisssement de la mise en valeur, se sont soldées par un net recul de la production agricole. Malheureusement, l'ampleur de ce recul n'est pas encore évalué pour l'ensemble de la zone. Mais une étude (1) de cas effectuée sur la plaine de Chotrana (district de Tunis) illustre bien ce phénomène et contribue à donner une idée de son ampleur. Cette étude a permis d'évaluer en quantité et en coût la perte

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(1) L'impact des scénarios d'aménagement du nord de l'Ariana sur la production agricole de la plaine de Chotrana.
A. Hentati, Direction des sols, 1985

de production agricole qu'occasionne l'application des scénarios d'aménagement d'une plaine agricole fertile agressée par l'urbanisation spontanée. Il se dégage que l'application des scénarios 1 et 3, qui accaparent chacun 120 ha aux dépens des terres de sauvegarde, occasionne une perte de 771 tonnes de produits agricoles (maraîchers et fruitiers) chaque année évaluée à environ 108 300 dinars tunisiens. Le scénario 2 qui prévoit l'urbanisation de 390 ha de terres de sauvegarde entraîne une perte de 2505,75 tonnes de produits agricoles évalués à 353.475 dinars. Or les 420 hectares qu'occupe actuellement le bâti étaient des terres fertiles productives de produits maraîchers. Si on considère que ces terres ont le même niveau de production que celles qui ne sont pas encore urbanisées, la perte de production agricole de l'ensemble de la zone est alors de 2520 tonnes par an sur plus de 20 ans.

Si on attribue une production moyenne annuelle de 5 tonnes par hectare aux 22.000 hectares de terres agricoles perdues entre 1962 et 1983 autour des villes de Tunis, Sfax, Gabès, Hammamet et Nabeul, le volume de production agricole soustraite de la production nationale serait de 2,2 millions de tonnes durant les 20 dernières années.

En outre, en plus du recul de la production agricole lié à la perte physique de la terre, les utilisations non agricoles entraînent également la détérioration des rendements des terres dans les campagnes environnantes. Cette baisse de rendement, observée partout dans la côte orientale, se traduit également par un recul plus important de la production agricole, ce qui rend la zone côtière, qui était parmi les régions agricoles les plus productives, très dépendante des zones intérieures dans son approvisionnement en produits maraîchers et potagers. Ceci est déjà un signe de déséquilibre qui affecte cette zone.

Sur ces problèmes de recul de la production agricole se greffent d'autres problèmes inhérents à l'alimentation en eau des industries, des hôtels et surtout des grandes villes dont le niveau de consommation dépasse de loin celui du secteur agricole. Or la zone côtière ne dispose pas de ressources en eau suffisantes. Ceci a entraîné la mobilisation de volumes importants d'eau dans les régions de l'intérieur pour les véhiculer à cette zone moyennant d'énormes infrastructures hydrauliques, tel le Canal Mejerdha - Cap Bon qui sera prolongé jusqu'au Sahel et Sfax.

Tout ceci se traduit par des efforts financiers importants qui ont des répercussions économiques profondes.

Vu l'importance et l'ampleur que revêt le phénomène de perte des terres agricoles par les utilisations non agricoles, le gouvernement tunisien a promulgué en novembre 1983 une loi pour la sauvegarde et la protection des terres agricoles contre les agressions engendrées par les utilisations non agricoles. Quelles sont les orientations de cette loi, ses portées et ses limites ? Les conclusions tirées après trois ans d'application de cette loi peuvent constituer des éléments de réponse à cette question.

5.4 La loi de protection des terres agricoles et ses effets après trois ans d'application

La loi 83-87 du 11 novembre 1983 s'inscrit dans le cadre des efforts déployés par les pouvoirs publics pour un aménagement meilleur du territoire et une rationalisation de l'affectation des sols aux différents secteurs de

l'activité économique et sociale. Promulguée en novembre 1983, elle est vite suivie par trois décrets et un arrêté définissant les voies et modalités de son application. Cette loi s'est basée sur la définition suivante des terres agricoles : sont considérées comme terres agricoles toutes terres présentant des potentialités physiques et affectées ou pouvant être le support d'une production agricole, forestière ou pastorale, ainsi que celles qui sont classées comme telles par les plans d'aménagement. Ainsi cette loi renforce directement les prédispositions du code de l'urbanisme et règlemente les changements de vocation qui peuvent survenir sur les terres agricoles définies dans leur sens le plus large. Pour ces raisons, cette loi classe ces terres en trois catégories qui sont :

- la zone d'interdiction
- la zone de sauvegarde
- la zone soumise à autorisation ministérielle.

Les zones d'interdiction couvrent les terres agricoles destinées à demeurer comme telles et comprennent les périmètres publics irrigués, les terres forestières relevant du domaine forestier ainsi que celles soumises au régime forestier à l'exception des terres de parcours. Dans ces zones, la modification de la vocation agricole des terres ne peut être opérée que dans le cadre des lois particulières les régissant.

Les zones de sauvegarde couvrent les terres agricoles dont la vocation agricole doit être protégée en raison de leur impact sur la production agricole nationale. Elles comprennent les terres fertiles, les autres périmètres irrigués, les terres plantées et les terres de parcours aménagés. Leur changement de vocation ne peut se faire que par décret et ce à la suite d'un avis émis par une commission technique consultative régionale des terres agricoles conçue à cet effet par la loi, et approuvée par le ministre de l'Agriculture.

Les terres soumises à autorisation ministérielle couvrent toutes les terres agricoles non comprises dans les zones d'interdiction et de sauvegarde.

Ainsi, cette loi couvre tout le territoire national et s'applique à toutes les terres sauf les étangs d'eau, les lacs et les sebkhas. Les ensembles dunaires de l'Erg oriental occupant le sud du pays sont assimilés à des terres mortes, donc non régis par cette loi. Seuls les secteurs mis en valeur dans cette zone sont considérés comme terre de sauvegarde.

En application de cette loi, le ministère de l'Agriculture a procédé à l'élaboration de cartes, appelées cartes des terres de sauvegarde pour chaque gouvernorat (1). Ces cartes délimitent, pour chaque gouvernorat, les zones d'interdiction, celles de sauvegarde et celles considérées comme soumises à autorisation. La délimitation des zones de sauvegarde a nécessité la mise au point d'une méthodologie basée sur l'identification de critères objectifs permettant de traduire facilement les caractéristiques intrinsèques du sol. Cette méthodologie, ayant utilisé les études pédologiques existantes et

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(1) Un gouvernorat représente la division administrative la plus large. La Tunisie est ainsi découpée administrativement en 25 gouvernorats dont 13 qui sont situés dans la zone littorale. 13 de ceux-ci constituent la côte orientale.

moyennant quelques expertises de contrôle, a pu délimiter à l'échelle du 1/50.000 pour les gouvernorats du nord et du centre et 1/100.000 pour les gouvernorats du sud, les zones de sauvegarde.

Une fois cette délimitation acceptée par des commissions spéciales groupant par gouvernorat les représentants des différents départements ministériels et des autorités régionales et locales, la carte de terres de sauvegarde est approuvée par décret, et devient la pièce maîtresse pour l'application de la loi de protection des terres agricoles conformément aux décrets et arrêtés d'accompagnement de cette loi.

Jusqu'à présent, les cartes de tous les gouvernorats côtiers et de quelques gouvernorats de l'intérieur sont déjà promulguées et constituent une référence de base pour l'application de la loi de protection des terres.

5.4.2 Les voies d'application de cette loi

A part les zones construites, les étangs d'eau et les sebkhats, toutes les terres sont considérées agricoles et classées selon les trois catégories par les cartes des terres de sauvegarde. Toute action menée pour une utilisation non agricole de ces terres correspond à un changement de la vocation agricole de celles-ci. Ce changement ne peut se faire qu'après avis du ministre de l'Agriculture. Cet avis est de trois types selon la classe de terre où se fait le changement.

Pour les terres d'interdiction, le changement de la vocation agricole d'un terrain doit passer par une loi qui révise la limitation du périmètre d'interdiction que celui-ci soit irrigué ou forestier. C'est donc une procédure longue et difficile.

Le changement de vocation dans les terres de sauvegarde nécessite l'approbation d'une commission technique régionale et du ministre de l'Agriculture qui procède alors à l'établissement d'un décret de déclassement du terrain demandé pour le faire sortir de la zone de sauvegarde. La procédure est également longue et difficile. Seule la procédure du changement de la vocation agricole dans les zones soumises à autorisation est relativement plus facile puisqu'elle est subordonnée à un arrêté de déclassement délivré par le ministre de l'Agriculture après que le demandeur ait présenté des accords de principe sur son projet fourni par le ministère chargé de l'urbanisme et le ministère technique concerné.

De cette façon toute utilisation non agricole des terres est étroitement contrôlée par l'administration et orientée vers les terres les moins fertiles. Ce contrôle s'effectue également sur le terrain par tous les ingénieurs des services de l'agriculture qui sont assermentés à ce sujet.

Ainsi, l'élaboration des plans d'aménagement urbains touristiques et industriels ainsi que des lotissments et l'implantation des carrières dépendent de l'avis du ministre de l'Agriculture. Plusieurs plans d'aménagement ont été obligés d'être modifiés pour acquérir l'approbation de ce dernier. Des dizaines de demandes de lotissements urbains et industriels ont été également rejetées.

5.4.3 Les problèmes soulevés par l'application rigoureuse de la loi de protection des terres agricoles

Le contrôle très strict sur les changements de vocation des terres a fait que les terres pour les utilisations non agricoles sont devenues relativement exiguës surtout autour des villes qui se trouvent dans les plaines fertiles.

L'exiguité des terres destinées à la construction pour l'habitation et l'industrie est susceptible d'engendrer une spéculation foncière encore plus grande si des mesures réglementant les prix du terrain de construction ne sont pas prises.

D'autre part, la réservation des terrains peu fertiles aux utilisations non agricoles a fait que le bâti, par exemple, est contraint d'occuper des versants incultes et des sites topographiques moins faciles que les sites de plaine. Ceci entraîne une surélévation des coûts de l'urbanisation, et demande de nouvelles mesures techniques pour la réadaptation des infrastructures et des équipements collectifs. Ceci se solde également par un gonflement du coût de mise en place de ces derniers.

Cependant, l'augmentation des coûts du terrain, de l'urbanisation ou des infrastructures et des équipements collectifs occasionnée par le contrôle très strict des utilisations non agricoles des terres n'est-elle pas le prix à payer pour la sauvegarde des terres et de l'activité agricole dans le pays qui est en quête de l'auto-suffisance alimentaire ?

6. TRANSFERT DE L'EXPERIENCE TUNISIENNE

Il est sûr que plusieurs pays méditerranéens disposent de cadres juridiques et de politiques visant la réglementation de l'allocation de l'espace.

Cependant, il faut avoir un dispositif facilement exploitable par les pouvoirs publics pour que le contrôle de l'affectation des terres soit facile et correct.

La Tunisie a élaboré ce dispositif par le code de l'urbanisme, la loi de protection des terres agricoles et ses décrets d'application et les cartes des terres de sauvegarde qui constituent le référentiel objectif de ce dispositif. Cette expérience tunisienne pourrait être facilement transférée à d'autres pays moyennant quelques adaptations au niveau législatif. Une copie de la loi et de ses décrets d'application fournie à n'importe quel pays peut lui permettre d'élaborer une législation semblable. Toutefois, l'application effective de la loi nécessite la mise au point de documents cartographiques délimitant les différents niveaux de fertilité des terres, ce qui nécessite une bonne connaissance des sols dans l'ensemble du territoire. Si cette connaissance n'est pas disponible, il faut envisager l'élaboration de cartes pédologiques au moins autour des villes et des zones cibles où les problèmes d'allocation de l'espace se posent au détriment des utilisations agricoles des terres.

La Tunisie peut, dans le cadre du CAR/PAP, faire bénéficier les pays méditerranéens de son expérience dans le domaine de l'élaboration de ces cartes.

D'autre part, il est recommandé que le CAR/PAP commence à réfléchir sur l'élaboration d'un code méditerranéen, ou la *préservation des utilisations* agricoles des terres et la planification des utilisations agricoles. Ce code, conçu de façon à être applicable pour toutes les situations méditerranéennes constitue un cadre efficace pour la sauvegarde de l'environnement et la protection des terres dans le monde méditerranéen.

7. CONCLUSION

Le contrôle des utilisations non agricoles des terres pour la sauvegarde de l'utilisation agricole de celles-ci est l'un des acquis les plus importants enregistré en Tunisie dans le domaine de la protection de l'environnement. En effet, le contrôle de l'extension de l'urbanisation et des installations industrielles permet de réduire au minimum les risques de dégradation de l'environnement par pollution. D'autre part ce contrôle a permis de sauvegarder l'activité agricole surtout autour des villes où les campagnes *jouent un rôle social et économique. Après trois ans seulement écoulés depuis* la promulgation de la loi de protection des terres agricoles, son application a donné beaucoup de satisfaction surtout dans la zone du littoral oriental où plusieurs installations industrielles ont été obligées de déménager pour sauver l'environnement en général et agricole en particulier. Des dizaines d'hectares de terres productives ont été également épargnés de l'agression urbaine.

Cependant, malgré les problèmes d'augmentation du coût de l'urbanisation inhérents à l'application de la loi de protection des terres agricoles, le bilan écologique et économique de celle-ci est de loin très positif. A ce sujet on recommande l'établissement d'un code méditerranéen de préservation des activités agricoles et de planification de l'affectation non agricole des terres.

8. RESUME

L'organisation économique des territoires necéssite un certain partage des affectations des terres en fonction de l'importance des activités sur lesquelles se base cette organisation. Toutefois, certains territoires évoluent vers une suprématie des utilisations non agricoles des terres aux dépens des utilisations agricoles. Ces dernières sont en train de perdre du terrain et surtout de l'importance, ce qui a engendré l'émergence de problèmes de dégradation de l'environnement (pollution) et de déséquilibre économique et social qui menace l'organisation économique du territoire. Ce phénomène, tangible pour plusieurs régions du monde, l'est encore plus pour les zones côtières méditerranéennes qui abritent les villes les plus dynamiques et les campagnes les plus riches du monde méditerranéen. L'étude et le dimensionnement du phénomène sur la côte orientale de la Tunisie présente un cas concret d'extension inconsidérée des utilisations non agricoles aux dépens des terres agricoles. La perte de milliers de tonnes de produits agricoles s'effectue chaque année suite au délaissement de l'activité agricole et au grignotage des terres fertiles par les constructions.

Les dispositions du code de l'urbanisme prises depuis les années soixante-dix n'ont pu freiner le phénomène. La promulgation de la loi de protection des terres agricoles en novembre 1983 et sa rigoureuse application

ont permis de faire face à ce problème et de diminuer son ampleur. Ceci a permis une meilleure gestion de l'espace, une préservation de l'environnement et de l'activité agricole, principalement autour des villes.

9. BIBLIOGRAPHIE

Bransia, M. (1986). Contribution à l'élaboration d'une méthode de classement des terres en vue de leur protection de l'extension urbaine. INAT-TUNIS.

Beaujeu-Garnier, Y. et G. Chabot (1969). Traité de géographie urbaine. Armand Colin, Paris.

Bechraoui, A. (1979). La vie rurale dans les oasis de Gabès.

Direction de l'aménagement du territoire (1975). "Ville et développement - Schéma national et schémas régionaux d'aménagement du territoire, 13 volumes, Tunis.

District de Tunis (1984). Bilan de l'urbanisation dans le District de Tunis de 1975 à 1983, Tunis.

Fakhfakh, M. (1976). "Sfax et sa région", Tunis.

FAO - "Les potentialités des terres pour la nourriture des populations des pays en développement". F.P.A./I.N.T/513, Rome 1984.

George, P. (1969). "Précis de géographie urbaine", F.U.F, Paris.

Hentati, M.A. (1975). Perte des terres agricoles et urbanisation dans la plaine de Chotrana (Ariana), D/Sol.

Jedidi, M. (1978). "La croissance urbaine au Sahel tunisien".

Moindrot, C. (1967). "Villes et campagnes britanniques", Coll. V2, Paris.

Plan bleu. "Perspectives sur la Méditerranée : Développement et environnement", Imprimerie Boudior, Paris, 1986.

Souissi, A. (1985). "Proposition de la protection du sol comme composant essentiel de la protection de l'environnement des zones côtières méditerranéennes", rapport national de la Tunisie.

SOIL CONSERVATION AND THE MEDITERRANEAN REGION : NEW DIRECTIONS?

by

R. GALLACHER
Soil Conservation Service
FAO, Rome

1. *INTRODUCTION*

Among common factors which have had, and continue to have, similar consequences for most Mediterranean countries, are:

- a common historical background; successive occupation of the coastal fringe by Phoenician, Greek, Roman, Arab traders or masters who have had a significant influence on the organisation of agriculture (and deforestation) and marketing, mostly with benefits flowing north and degradation spreading in the south. The long Roman presence has had the most lasting effects, mostly in the degradation of the south and east; this is probably due to the creation of agricultural exploitation and extension/marketing structures which later collapsed to a large extent, following the temporary withdrawal of knowledge, with the demise of the Byzantine empire;

- a common climate; parts of the south and east are arid lands with less than 75 days annual growing season and a rainfall annual average of 200 to 400 mm. Other parts of the south and north are semi-arid lands with 75 to 120 days effective growing season per year, from an average annual rainfall of 200 to 500 mm on the coastal band 50-70 km wide.

There are also sub-humid areas with longer growing periods and a greater annual rainfall, but even this area, in common with the other two types, has unpredictable winter rainfall, a dry summer with a high risk of grass and forest fires, and the constant possibility of torrential, erosive rains falling on bare soils.

Mediterranean-like climates exist in other parts of the world, mostly in the southern hemisphere, but countries in that part of the world do not have the same trade and development connections.

In short, it is obvious that the Mediterranean coastal belt is a unique and special region with enormous possibilities for interchanges on trade and technology.

Another less fortunate common factor is the extensive degradation already hinted at, particularly common in the south and east, but increasingly also in the north.

This seminar itself is evidence that a common problem once again brings Mediterranean countries together for consultations, at the initiative of the PAP/Regional Activity Centre and with the assistance of ACSAD and FAO.

2. THE PROBLEM

It can now be observed that the end result of these factors is falling productivity; the cause may be attributed to soil erosion and degradation because of misuse of the land. The problem however is neither as simple nor as straightforward as that; some of the following constraints, singly or together, constitute factors which accelerate degradation: (1)

- excessive human and livestock concentration;
- a lack of political priority given to rural development;
- inappropriate pricing policies for agricultural produce, particularly livestock;
- a lack of effective inputs and inadequate marketing or produce transformation services;
- a lack of sufficient technical and administrative personnel to initiate and direct change;
- a lack of appropriate and applicable research results in agriculture and forestry;
- a partial failure of extension methods;
- the lack of an integrated approach in the solution of the overall problem.

The above are socio-economic and institutional constraints; additionally, the following resource and physical constraints are very important:

- soil erosion and declining soil fertility, as well as unpredictable droughts which lead to erratic production (as mentioned before);
- overgrazing;
- shortage of fuel wood and forage;
- an incomplete assessment of the natural resources of land, water and vegetation.

3. GENERALLY-ACCEPTED SOLUTIONS

The World Soil Charter, adopted by the 21st session of the FAO Conference in November 1981, sets out Principles for soil care, Guidelines for action and Possibilities for follow-up.

A submission was made to the ninth session of the Committee on Agriculture (COAG) on 26 and 27 March 1987 entitled "Improving productivity of dryland areas", from which the above constraints are drawn; the whole world's drylands are in question and policy decisions are put forward for each situation, which might overcome the constraints.

In an annex to this COAG paper, there is a series of proposals for dryland technologies in respect of livestock and crops. The lists contain some advances as well as some constraints. During the discussions, the delegates further updated the lists, in accordance with the general principles.

To bring about a more profound knowledge of soil conservation, erosion and its consequences and application of appropriate strategies, the Soil Conservation Group of the Land and Water Development Division of FAO, has refined the subject in the following ways:

More recent orientations

After evaluation of those agricultural development projects with a conservation objective carried out over the past few years, it has become more and more apparent that long and short-term failures are more common than successes in the overall achievement of goals, not only in the subject area of maintaining or increasing productivity, but also in the general reclamation of degraded sites.

This has led to an examination of the reasons for failure, whether these be due to poor project design in general, or more specifically confined to research areas into the mechanisms of erosion.

Evidence is mounting, from recently-commissioned studies, that the problems are much more complex than originally envisaged and that classic solutions and treatments often exacerbate the problems.

In order to quantify the erosion problem, Dr M. Stocking of the University of East Anglia was commissioned to re-examine old records from runoff-measuring plots [(2)]. This follow-up exercise to the review of a number of papers dealing with the relationship between erosion and the loss of soil productivity [(3)] showed that a strong relationship could be demonstrated. Stocking then produced a paper [(4)] outlining a research design so that this trend could be verified at field level; he is at present in the process of aiding several countries to set up plots to monitor the erosion/productivity loss relationship.

In the interim period, the records from the old runoff-measuring plots in Zimbabwe, subjected to various analyses by computer, showed a distinct pattern of correlation which allowed Stocking to make some firmly-based conclusions. He was careful not to extend the conclusions beyond the existing evidence, but, for less scientific persons reading between the lines, a picture is beginning to emerge which indicates that, as suspected, vegetative cover and soil management intended to maximise raindrop interception before raindrop impact on bare soil, can lead to "splash" erosion which carries away the most mobile plant nutrients in solution with the early rains, and is the most important facet of erosion prevention and the mitigation of productivity loss.

The above-mentioned records came from four different soils in different parts of Zimbabwe and Stocking was able, provisionally, to assign a value to the quantities of eroded nitrogen and phosphate compounds and thus, to assign a theoretical cost per ha of replacing the lost elements with artificial fertilisers (N-P) at current market costs; then, by projection, the national cost of soil erosion can be outlined for those countries where no provision is being made.

If nutrient elements become mobile with the earliest rains of the season when runoff occurs and the runoff is evacuated by diversion banks and waterways, in the classic manner, then the farmer is sending the elements of his crop productivity off his fields, by the quickest means, to his neighbours or into streams, rivers, lakes or the sea. Conversely, if everything possible is done to intercept raindrops with vegetation, and infiltrate the water slowly into a well-structured soil which contains sufficient amounts of organic matter in the upper profile, live vegetation or mulch on the surface to reduce evaporation and copious numbers of microflora and fauna in the soil to maintain the health of that soil (by correct tillage methods and subsequent rotations and other management) then it is assumed that the soil productivity will automatically increase. This view, however, may be simplistic and more research is needed.

One may well question the role of contour banks in this light; they may prevent nutrients from leaving the field (if the banks do not over-top or break) and "enrich" the soil against the bank, but what about the rest of the field? What is a narrow ribbon of higher-yielding wheat against the bank worth, if the rest of the crop hardly returns the seed which was sown?

The work by Stocking, and the current studies by Professor N.W. Hudson on the reasons for success or failure of soil conservation projects, raise certain issues for further soil conservation research:

- the examination of management solutions and low-input natural or traditional solutions to increasing soil productivity; this has an inbuilt implication that less emphasis should be placed on engineering, high-input and technologically-complex solutions (which usually means high-cost inputs and high managerial capabilities);
- a search for alternatives to physiographic project boundaries (administrative/socio-economic or marketing-unit boundaries);
- an attempt to identify inputs and solutions which address an entire programme [5], rather than tackling a single problem within a defined project "pilot demonstration";
- a re-examination of the whole field of soil management, tillage and biological solutions with the object of enhancing organic matter buildup in the soil, in an attempt to find various compromise solutions;
- research into interception/infiltration/storage techniques for rainfall, instead of the classic pre-occupations with diversion and water evacuation;
- work towards a sustained agricultural income by means of diversity of enterprises on-farm, better rotations and fuller land-surface occupation throughout the seasons;
- recognition of the need for compromise solutions in a more complete integration of livestock, subsistence crops, energy sources and water storage, ranging from cash-based economies to barter and self-sufficiency systems;
- the need from the collaborating governments and ministries within those governments, for patience, tolerance and assistance to arrive at the optimal solutions;

- the role of subsidies; too many subsidies make for new problems;

  Yet the lack of incentives to farmers has turned a drought into a major famine in some African countries, with resulting massive soil degradation and loss of human life, a lack of crop residues to sustain livestock and a lack of animal manure for fuel; the conservationist is faced with a "balancing act" through a series of compromises.

4. NEW TECHNOLOGIES

Much emphasis is placed (sometimes erroneously) on the future development of new technologies. Yet there are many old, even traditional techniques which could be put to better use. This is particularly the case with soil management and tillage; often, the ingredient lacking is sensitive planning and enlightened management. Consider the following:

".....nothing has been more corrosive..... than the historically recent notion that a farmer has an unfettered right to do what he pleases with his land," (6)

and:

"Every subsidy aimed at farmers and landholders - whether it be price support, a development grant, official advice (land), rate relief, tax concessions on fuel, machinery and chemicals, or even cash-in-hand for conservation - all of them lead to unnecessary capital formation, to excessive borrowing from banks and from nature, to the artificial bidding-up of land values and to ever greater pressures to increase productivity and the rate of profit" (7).

It is in fact the strategies which need upgrading, rather than the technologies.

To continue in this vein, "....(options are)...restructuring agricultural support, or conservation incentives, or planning controls....these approaches are not compatible. ....A workable package of reforms must contain elements of each" (8).

FAO's Land and Water Development Division's motto has become "Protect and Produce"; taking the single example of the U.S.A., where an estimated average topsoil loss from cropland is in the vicinity of 12 tonnes per ha, this alone represents some 50 million tonnes of plant nutrients lost every year, which are being partly replaced with expensive artificial fertiliser (9). An arid to semi-arid environment such as the Mediterranean region can much less afford a comparable loss.

5. BIBLIOGRAPHY

Cahill, D.N. (1985). A programme approach to soil conservation. (6 pp.) Paper to Malama Aina 83, Honolulu; In: Soil Erosion and Conservation (edited El Swaify et al.), SCSA. ISBN 0 935734 11 2.

Lowe, Cox, Macewen, O'Riordan and Winter (1986). Countryside conflicts. Gower Publ. ISBN 0 566 050889.

FAO (1982). World Soil Charter (Prepared for Committee on Agriculture, presented and approved by FAO Conference, 1981).

FAO (1984). Protect and Produce. By Land and Water Development Division of FAO (English, French, Spanish, Arabic). I/Q5110/(EFSA)/E11.84/2/3500.

FAO (1987). Improving agriculture of dryland areas: Committee on Agriculture of FAO; Sir Charles Pereira (Ed), 22 pp.

FAO (1987a). Medium and long-term outlook for food and agricultural development: Committee on Agriculture No.9, FAO; 3 pp.

Stocking, M.A. (1984). Erosion and soil productivity: A Review. University of East Anglia and FAO (Mimeo 102 pp.).

Stocking, M.A. (1986). Erosion-induced loss in soil productivity: A Research design. University of East Anglia and FAO (Mimeo 33 pp.).

Stocking, M.A. (1986). The cost of soil erosion in Zimbabwe in terms of the loss of three major nutrients (Mimeo 164 pp.).

Stocking, M.A., and L. Peake (1985). Erosion-induced loss in soil productivity: trends in research and international cooperation (Mimeo 52 pp.). Maracay, Venezuela conference papers: IV International Conference on Soil Conservation.

REMOTE SENSING AND SOIL EROSION
(Background note)

by

J.A. HOWARD
Remote Sensing Centre (AGRT)
FAO, Rome

FAO has used remote sensing in studying factors associated with soil erosion for many years. The FAO Remote Sensing Centre (FAORSC) has undertaken several studies related to soil erosion and land use in cooperation with the FAO Soil Resources Management and Conservation Service. These studies range from the production of reports, maps and photographic mosaics at scales between 1:10.000.000 (Namibia) through scales 1:1.000.000 - 1:250.000 (Landsat) and more recently, pilot studies at 1:100.000 - 1:50.000 (SPOT). Smaller scale studies at regional, sub-regional and national levels have used primarily Landsat multispectral (MS) data and more recently, Landsat TM at 1:200.000 (Lebanon) and Landsat TM and SPOT at 1:100.000 (Maldives) and SPOT at 1:50.000 (Kenya).

The study of Namibia (slide 1) which could not avail itself of ground truth, indicates what is feasible for preliminary reconnaissance for an extensive area of approximately 825,000 km^2 (cf. Mediterranean 5 million km^2). *The legend provides for the division of Namibia into major land units* based on land forms and soils, and provides four land suitability classes and four agro-climatic zones (woodland, bushland, semi-desert, desert).

More intensively, and involving some ground truth, Landsat MSS imagery was interpreted in detail at 1:3.250.000 scale to provide regional soil degradation maps on a 1:5.000.000 scale. This involved the study of a strip 160 km wide from the high rainfall areas of Liberia, through the savannah woodland areas of Côte d'Ivoire and Burkina Faso to the semi-arid shrublands (Sahel) of Burkina Faso and the arid deserts of Mali and Niger and was followed by a second study across Jordan into Iraq. The derived legend (slide 3) was tested for the entire country of Iran for which two maps were prepared: (a) morpho-dynamic, and (b) vegetation cover and land use (slide 2). In the testing, only three new categories had to be added to the legend and the Iranian study was completed in 3.1/2 man-months. It was concluded that this remotely sensed legend was robust, international and ready for further testing on a world-wide basis (slide 3). Possibly, the legend, with modifications, could be used as a basis for developing a regional soil erosion legend and map of the Mediterranean basin using satellite imagery in a relatively short period of time.

At a national level, attention is drawn to the land system classification of Jordan which was completed in approximately 3 man-months. Landsat MSS was used to identify complex/compound land systems, which were further divided into simple land systems using stereoscopic pairs of aerial photographs. Stereopairs of aerial photographs and field checking provided a basis on which to construct block diagrams of all identified land systems. Slide 4 shows the Landsat mosaic of Jordan with delineated land systems. Slide 5 provides a close-up of this photomosaic and depicts land systems 12.1, 12.2 [illegible] 4. Block diagrams of these land systems are provided in slides 5a, b and c.

A recent study carried out in Kenya using SPOT digital tapes to provide MS imagery indicates that SPOT MS is admirably suited to within-country studies using simple land systems as the base (Howard & Lantieri, 1986) (slide 6). Mapping at a scale of 1:50.000 from enhanced imagery of SPOT MS data is feasible. Simple land systems are readily identifiable in terms of the conspicuous landforms, vegetation patterns and colour differences. Landsat TM could be somewhat similarly used for within-country studies but is of a lower resolution than SPOT (i.e. 30 m vis-à-vis 20 m). Slide 7 shows part of a photomosaic prepared by the FAORSC using Landsat TM and may be compared with the same area (Beka valley) of the Lebanon which used Landsat MSS (slide 9).

In conclusion, it is suggested that earth resources satellite imagery could provide a useful base on which to initiate soil erosion studies of the Mediterranean basin. This could be followed up using second generation earth resources satellite data for mapping, and to assist in collecting statistics at the national level and at the local level within countries. A landscape approach using remote sensing imagery can readily provide homogeneous land units at magnitudes ranging from the regional level (e.g. land provinces) to the local level (e.g. land systems, land facets). The initial database could be developed through multilateral co-operation in remote sensing.

DRAFT JOINT PROJECT PROPOSAL

INVENTORY AND NETWORK OF EROSION MANAGEMENT IN THE MEDITERRANEAN FOR ENVIRONMENTALLY-SOUND LAND MANAGEMENT

PREPARED BY PAP/RAC, IN CO-OPERATION WITH FAO

1. BACKGROUND

Rainfall-induced erosion is the most widespread and most significant form of soil degradation in Mediterranean coastal zones. Wide general knowledge related to this phenomenon has been developed, whereby the understanding of Mediterranean specific features is insufficient and acquired on different using non-standardised methodologies. Therefore the methods of assessment and prediction of erosion hazard as well as the protective measures are insufficiently founded, with consequences leading to their lack of efficiency.

Some attempts have been made in the Mediterranean region to obtain, on an experimental basis, data necessary for the enhancement of relevant measures. However, these experiments are not coordinated, thus hindering the comparison and joint data processing. In order therefore to increase the necessary specific knowledge, to create a common methodology, and to improve the data processing, a co-ordinated Mediterranean project in the field is proposed. This proposal was first put forward at the PAP meeting of experts on Soil Protection held in November 1985.

FAO has long been closely involved in this area, and has considerable experience as well as a permanent interest in it. PAP, as a component of the Mediterranean Action Plan, is in the process of implementing that part of its programme on the priority action on soil protection in the Mediterranean coastal zones as part of the protection of the Mediterranean Environment. ACSAD, The Arab Centre for the Studies of Arid Zones and Dry Lands, is also actively engaged in this activity in Mediterranean Arab countries, and has expressed its interest in co-operation in this field.

2. OBJECTIVES OF THE PROJECT

The long-term objective of the project is to contribute to the advancement of soil protection of Mediterranean coastal zones from rainfall-induced erosion as a component of environmentally-sound land management.

The immediate objectives of the project are:

- to make a presentation of the "state of the art" related to soil erosion in the Mediterranean coastal areas, including a statement for decision-makers, of the expected benefits from the implementation of appropriate policies;

- to make an inventory (thematic maps on erosion distribution, the rate of erosion and the different forms of erosion) in the Mediterranean coastal areas, based on remote sensing techniques;

- to create a Mediterranean network of institutions and erosion monitoring procedures, with the aim of testing various soil and crop management options leading to the mitigation of erosion;

- to create a common methodology and programme of observation of rainfall-induced erosion phenomena;

- to establish a relevant information system as the base for data processing;

- to implement the training of national experts from participating countries;

- to produce a synthesis report which includes a summary for decision-makers and to formulate conclusions and recommendations as well as proposing a follow-up; also, to ensure the dissemination of results and findings by appropriate means;

- to produce recommendations for environmentally-sound land management.

3. CONTENTS OF PROJECT

The following activities are envisaged:

- preparation of a statement of "state of the art" of soil conservation in the Mediterranean coastal areas;

- production of thematic maps;

- workshop to discuss thematic maps produced and on the basis of these maps, to propose sites for network erosion monitoring;

- localisation and establishment as appropriate of new erosion monitoring sites, in addition to approved existing sites and measuring installations;

- development of a common evaluation methodology;

- monitoring of:

  (a) meteorological parameters
  (b) impact of human activities on soil erosion and the ecosystem
  (c) hydrological parameters and sediment

- establishment of information systems and methods of data processing;

- preparation of a synthesis report, conclusions, recommendations on proposals for the follow-up;

- recommendations production for environmentally-sound land management;

- final workshop to present project results.

4. APPLICABILITY OF THE PROJECT

The results of the project are to be used by:

- institutions and experts in the field for a better knowledge of erosion phenomena;
- institutions and experts concerned with planning and implementation of erosion control measures;
- decision-makers concerned with the formulation of relevant national policies and implementation of measures for the prevention, as well as the mitigation of soil erosion.

5. OUTPUTS

The project will produce the following outputs:

- a prepared submission of "state of the art" with an executive summary for decision-makers;
- thematic maps relevant to rainfall-induced erosion;
- an intermediate workshop report;
- a network of Mediterranean institutions with runoff monitoring sites, functioning as a coordinated system;
- information systems and data processing methods;
- training of national specialists and the use of the sites for demonstration of effects of different measures on erosion control;
- more effective erosion control projects for the future, based on accumulated data;
- a synthesis report and an executive summary for decision-makers, conclusions, recommendations and proposals for the follow-up;
- recommendations for environmentally-sound land management;
- a final workshop report.

6. IMPLEMENTATION OF THE PROJECT

The preparatory activities will be carried out by a working group of experts, guided by the elected project manager.

PAP/RAC will contact the Governments of Mediterranean countries interested in participating in the project, and the working group will proposé those pilot stations suitable for monitoring, and after a visit to the sites, will formulate the draft project proposal. The project will be [illegible] with the assistance and coordination of FAO, ACSAD and PAP/RAC.

The organisational aspects will be discussed with interested countries and formulated accordingly in the draft project proposal.

7. TIME SCHEDULE

The following time schedule is envisaged:

(a) Preparatory activities (PAP/RAC): 6 months of activities including consultancies, meetings, and the preparation of remote sensing exercise : June-December 1987;

(b) Main project: finalising "state of art" reports and first stage thematic maps presentation : January-April 1988;

(c) Intermediate workshop : May 1988;

(d) Network establishment and functioning, methodology development: January 1988-November 1989;

(e) Development of information systems, testing data processing methods: January 1988-November 1989;

(f) Training courses and preparation of final workshop: January 1988 - November 1989;

(g) Recommendations' finalisation : December 1989;

(h) Final workshop : December 1989.

8. FINANCIAL ASPECTS

It is envisaged that the participating countries will contribute to the project, covering in national currencies and in kind, costs related to the activities on their territories.

The project will support the costs of the "state of the art" report and thematic maps as well as coordination, preparation of common methodology and information system, necessary additional equipment for monitoring stations, training of local experts, preparation of local and synthesis reports, printing of documents and organisation of the final workshop.

The amount of funds necessary for these purposes is estimated at $500,000 for joint activities, and an additional $200,000 for the total of experimental plots and $300,000 for thematic maps. A detailed budget will be elaborated in the draft project proposal as will the sharing of necessary contributions.

CONCLUSIONS AND RECOMMENDATIONS OF THE SEMINAR ON SOIL PROTECTION IN THE MEDITERRANEAN COASTAL ZONES

(Split, 1987)

1. CONCLUSIONS

The following conclusions were adopted by the seminar:

1. It was confirmed that rainfall erosion presents the most serious form of soil erosion, and threatens the entire environmental and socio-economic system in Mediterranean coastal zones.

2. In relation to the coastal environment, arable agricultural land and forest-grassland areas should be given equal consideration.

3. In addition, reduced soil productivity and sediment movements are of equal significance, as consequences of erosion processes.

4. The existing knowledge of the research status of erosion processes shows that some general information on water erosion cannot be applied to specific Mediterranean conditions without first being tested, that the levels of research and measurement of erosion-related parameters are not uniform and that these depend on the prevailing conditions in each country, on its policy with respect to soil use and traditional cultivation.

5. Studies of Mediterranean coastal zones did not adequately cover the local problems of increased erosion, either due to shortcomings of the protection services, or because national priorities were channelised elsewhere.

6. A detailed inventory of occurrence, form, and intensity of erosion through the preparation of erosion maps is a prerequisite for combating erosion and for any form of co-operation to be successfully established. Such inventories have been prepared in several Mediterranean countries, though they differ in method and professional level. The possibilities offered by modern remote sensing techniques have been inadequately exploited so far in the preparation of erosion maps and the monitoring of erosion processes.

7. The development of erosion risk prediction models and the collection of data required in the planning of erosion combating measures calls for long-term and intensive experiments. The relevant research has been carried out in some Mediterranean countries, and the results are applicable to other coastal countries.

8. There is a growing awareness of the need for an integrated approach to catchment management in the planning and construction of erosion combating measures. The degree of implementation of such an approach varies from one Mediterranean country to another. The major obstacles to a consistent implementation of that concept are:

- an insufficient knowledge of the concept and methods for integration of various relevant activities;

- the necessity to integrate new approaches with traditional soil protection techniques used by major disciplines (agriculture, forestry, soil engineering, hydrology);

- the difficulties resulting from the introduction of radical changes in the ways of land use and farming and their acceptance by farmers;

- an inadequate information basis for planning such activities.

9. Afforestation has proved to be a very efficient measure in erosion prevention and the reclamation of seriously disturbed ecosystems. The problems pertaining to tree species, specific afforestation techniques of erosive terrains, and to land use classification, which are to justify the afforestation, are of the utmost importance.

10. Identification of different types of catchment areas is essential for the promotion of integral catchment management.

11. In addition to a lack of technical equipment (pluviographs, limnigraphs, rain simulators, etc.), the developing Mediterranean countries need technical assistance, expert missions to resolve specific problems, and training organised in Mediterranean centres of advanced practice.

12. The loss of agricultural land due to marine erosion has occurred in a number of Mediterranean countries.

13. Although there are differences as to many relevant aspects of erosion, there is a real need for co-operation between Mediterranean governments, institutions and experts, if an efficient protection against erosion is to be obtained.

14. The loss of agricultural land due to urban expansion, as well as for other reasons, has increased considerably in the Mediterranean region. The causes of this phenomenon are the uncontrolled growth of towns, inadequate land use planning policies, population migration to the narrow coastal strip, uncontrolled building, and reluctance to apply the existing laws. Unless coordinated and appropriate measures are taken in all countries, this phenomenon will have catastrophic consequences.

15. The abandonment of agricultural land and land fragmentation reduce the degree of utilisation of the available agricultural land.

2. RECOMMENDATIONS

The following recommendations were adopted by the seminar:

1. The problems associated with rainfall-induced soil erosion are to remain the focus of activities within the priority action on soil protection in the next period, to be supported by all available forms of cooperation.

2. The activities should be particularly directed to the working-out and implementation of the cooperative project entitled "Inventory and Network of Soil Erosion Measurement in the Mediterranean for Environmentally Sound Land Management". Formulated in this way, yet representing a single theme, the project covers three important problems of rainfall erosion:

(a) the preparation of thematic erosion maps as the basis for planning future actions and an effective exchange of experience;

(b) the establishment of a complementary and well co-ordinated network of measuring stations to provide reliable data required in soil protection;

(c) the steering of all relevant activities towards the development of an integrated catchment management as the most effective method of the optimum environmental protection in coastal zones.

3. Each part of this integrated project can be launched as an independent action within the financial resources provided. It is, therefore, recommended that PAP/RAC undertakes, jointly with FAO, if possible, the following actions in the next period:

- the continuance of the activities aimed towards the promotion and preparation of the cooperative project, as well as securing the necessary financial support for its implementation;

- the organisation of expert missions associated with the project, upon request from the countries concerned and when such requests fit in with the overall concept of the project;

- the identification and nomination of centres for implementing activities within the project, in co-operation with the National Focal Points for PAP;

- the definition of current needs for equipment and the estimation of the possibility of providing such equipment as technical assistance to the developing countries;

- the promotion of the application of modern surveying and mapping methods, including remote sensing techniques, to improve the quality of information needed by the project;

- the promotion of the application of the concept of integrated catchment management as the method which offers the optimum protection of the environment, in securing the participation and approval of the local population;

- the organisation of workshops for the exchange of experience and the establishment of a network of relevant national institutions.

4. In order to cover all the erosion-related issues, PAP/RAC should consider the issues of forest-fires in the wider context of activities pertaining to soil protection.

5. Studies related to marine erosion of coastal strip must be improved and the exchange of experience on this subject must be promoted.

6. In order to protect agricultural land against urban expansion and other non-agricultural uses it is recommended that some integrated and co-ordinated measures be taken, such as:

- the preparation of land suitability maps;
- the monitoring of land use and erosion processes;
- the application of adequate measures of taxation and economic stimulation;
- the prevention of land fragmentation due to successive inheriting;
- the implementation of measures which give priority to farmers for the acquisition of agricultural land;
- the adoption of measures to secure the application of the relevant laws.

7. PAP/RAC should examine the possibility of preparing guidelines for the formulation and implementation of measures for the protection of agricultural land.

8. PAP/RAC should make a detailed survey in all Mediterranean countries with a view to preparing an inventory of all measures and regulations in force in each country, as well as of governmental and similar interventions directed to the protection of fertile lands from non-agricultural uses.

CONCLUSIONS ET RECOMMANDATIONS DU SEMINAIRE SUR LA PROTECTION DES SOLS DANS LES ZONES COTIERES MEDITERRANEENNES

(Split, 1987)

1. CONCLUSIONS

Les participants au séminaire ont adopté les conclusions suivantes:

1. Il a été confirmé que l'érosion hydrique provoquée par le ruissellement est la forme la plus grave de dégradation des sols, menaçant sérieusement le système environnemental et socio-économique dans les zones côtières de la Méditerranée.

2. En ce qui concerne la protection de l'environnement, la même attention devrait être portée aux terrains agricoles qu'aux pâturages et forêts.

3. De même, une attention particulière doit être prêtée à la diminution de la productivité des sols et aux mouvements des sédiments, en tant que conséquences du processus d'érosion.

4. Les connaissances actuelles concernant l'état d'avancement des recherches sur les processus d'érosion dans les zones côtières méditerranéennes démontrent que certaines connaissances générales sur l'érosion hydrique ne sont pas applicables dans les conditions méditerranéennes spécifiques sans test préalable et que les recherches et les mesures des paramètres relatifs aux processus d'érosion ne sont pas standardisées et qu'elles dépendent des conditions propres à chaque pays et de la politique d'utilisation des ressources.

5. Les études relatives aux zones côtières ne sont pas suffisamment développées pour couvrir d'une façon adéquate les problèmes d'érosion croissante, dû soit à l'insuffisance des services soit à la non conformité avec les priorités nationales.

6. L'inventaire des dimensions, des formes et de l'intensité de l'érosion au moyen de l'élaboration des cartes d'érosion est une base indispensable pour la lutte contre l'érosion et l'établissement de toute forme de coopération. De tels inventaires ont été effectués dans plusieurs pays méditerranéens, mais suivant différentes méthodes et à des niveaux professionnels différents. Les possibilités offertes par les techniques de télédétection n'ont pas été suffisamment exploitées pour la mise au point des cartes d'érosion et la surveillance continue des processus d'érosion.

7. Pour le développement des modèles de prévision du risque d'érosion ainsi que pour l'acquisition des données indispensables pour la planification des mesures de lutte contre l'érosion, il est nécessaire d'entreprendre des expériences intensives au cours d'une longue période. Ces recherches sont développées dans certains pays méditerranéens et leurs résultats sont applicables même dans d'autres pays côtiers.

8. Dans la planification et la mise en oeuvre des mesures de lutte contre l'érosion, on constate une prise de conscience accrue de la nécessité d'une approche intégrée de l'aménagement des bassins versants, mais le niveau d'application de cette approche diffère d'un pays méditerranéen à l'autre. Les principaux obstacles à une application stricte de ce concept sont les suivants:

- connaissance insuffisante de ce concept et des méthodes d'intégration de diverses activités pertinentes;

- nécessité de mettre en oeuvre de nouvelles approches prenant en considération les techniques traditionnelles de protection du sol dans la plupart des domaines (agriculture, foresterie, travaux du sol, hydrologie);

- difficultés provoquées par l'introduction de changements radicaux sur le plan d'utilisation des terres et d'exploitation des fermes et leur acceptation par les agriculteurs;

- insuffisance d'informations de base nécessaires à la planification de ces activités.

9. Le reboisement s'est avéré être une mesure efficace de prévention de l'érosion et d'amélioration des écosystèmes dégradés. Les problèmes liés au choix du type d'arboriculture, aux techniques spécifiques de reboisement des terrains érodables et au classement des vocations des sols, qui doivent justifier le reboisement, sont d'une importance primordiale.

10. L'identification de différents types de bassins versants est essentielle pour la promotion de leur aménagement intégré.

11. En plus d'équipements techniques (pluviographes, limnigraphes, simulateurs de pluie) les pays méditerranéens en voie de développement ont besoin d'une assistance technique consistant en mission d'experts pour la résolution de certains problèmes spécifiques et en formation de leurs experts dans des centres méditerranéens renommés.

12. Le phénomène de perte des terres agricoles due à l'érosion marine est présent dans certains pays méditerranéens.

13. Nonobstant les différences quant aux divers aspects de l'érosion, il est nécessaire d'établir une coopération entre les gouvernements, institutions et experts méditerranéens pour parvenir à une protection efficace contre ce phénomène.

14. La perte des terres agricoles due à l'expansion urbaine ou pour d'autres raisons est de plus en plus importante dans la région méditerranéenne. Les causes principales de ce phénomène sont: la croissance incontrôlée des villes, l'application inadéquate des politiques d'aménagement du territoire, les mouvements migratoires vers la côte, l'urbanisation anarchique, et l'application inadéquate des lois existantes. Si des mesures coordonnées et appropriées ne sont pas prises dans tous les pays méditerranéens, ce phénomène aura des conséquences catastrophiques.

15. L'abandon des terres agricoles et le morcellement des exploitations réduisent le niveau d'utilisation des terres agricoles disponibles.

2. RECOMMANDATIONS

1. Les activités à engager dans la période qui vient au sein de cette action prioritaire doivent être concentrées sur les problèmes d'érosion par la pluie et s'appuyer sur toutes les formes possibles de coopération.

2. Ces activités devraient viser en premier lieu à la formulation et la réalisation du projet de coopération intitulé "Inventaire et réseau de contrôle de l'érosion en Méditerranée pour une gestion du sol sans préjudice pour l'environnement". Ce projet, bien qu'un ensemble unique, englobe trois problèmes importants liés à l'érosion par la pluie:

(a) l'établissement des cartes d'érosion comme base pour la planification des actions futures et l'échange d'expérience;

(b) l'établissement d'un réseau coordonné et unifié de stations de mesures fournissant les données nécessaires à la protection du sol; et

(c) l'orientation des activités vers le développement de l'aménagement intégré des bassins versants en tant que méthode la plus efficace de protection des milieux côtiers.

3. Chaque segment de ce projet intégré peut être lancé en tant qu'une action indépendante, en fonction des ressources financières disponibles. Cependant, on recommande au CAR/PAP d'entreprendre conjointement avec la FAO ce qui suit:

- poursuivre les activités visant la promotion et la préparation du projet de coopération et assurer le soutien financier nécessaire à sa mise en oeuvre;

- organiser des missions d'experts liées au projet, et ceci à la demande des pays et sous condition que leur demande soit conforme au concept général du projet;

- identifier et désigner, en collaboration avec les structures focales nationales du PAP, les centres qui seront chargés de la mise en oeuvre de diverses activités dans le cadre du projet;

- définir les besoins en équipements et examiner les possibilités de les fournir aux pays en voie de développement en tant qu'assistance technique;

- promouvoir l'application des méthodes les plus performantes utilisant les techniques de télédétection pour la cartographie et l'élaboration des relevés, qui pourraient fournir des informations de qualité demandée par le projet;

- promouvoir l'application du concept d'aménagement intégré des bassins versants en tant que méthode qui offre une protection optimale de l'environnement, en accordant une importance primordiale à l'adhésion et à la participation de la population locale;

- organiser des ateliers de travail afin de faciliter l'échange d'expériences et l'établissement d'un réseau d'institutions nationales concernées.

4. Afin de couvrir tous les facteurs d'érosion, le CAR/PAP devrait prendre en considération mêmes les problèmes d'incendies de forêts dans un contexte plus large des activités relatives à la protection du sol.

5. Il sera nécessaire d'améliorer les études relatives à l'érosion marine des côtes et de promouvoir l'échange d'expériences en ce domaine.

6. Aux fins de la protection des terres agricoles contre l'expansion urbaine et autres utilisations non agricoles, on recommande la prise de certaines mesures harmonisées et coordonnées, telles que:

- l'élaboration de cartes précisant l'affectation actuelle et à venir des terres;

- la surveillance continue de l'utilisation du sol et des processus d'érosion;

- la mise en application de mesures adéquates à caractère disuasif (telle que l'imposition de taxes) ou stimulantes (octroi de crédits avantageux);

- l'adoption de mesures empêchant le morcellement des exploitations dû aux droits de succession;

- la mise en application de mesures assurant aux agriculteurs la priorité dans l'acquisition des terres agricoles;

- la prise des mesures assurant une application stricte des lois en vigueur.

7. On recommande au CAR/PAP d'examiner les possibilités de préparation d'un guide pour la formulation et la mise en application de mesures de protection des terres agricoles.

8. Il est souhaitable que le CAR/PAP fasse une enquête détaillée de tous les pays méditerranéens pour procéder à l'inventaire de toutes les mesures et réglementations adoptées par ces pays ainsi que des interventions étatiques ou paraétatiques effectuées en vue de protéger la consommation des terres fertiles par des utilisations autres qu'agricoles.

Liste des documents

(Séminaire, Split, 1987)

1. Rapport national algérien (par B. Trabelsi)
2. National report of Cyprus (by A. Pissarides)
3. Egyptian national report (by E. Monem Balba)
4. Rapport national français (par F. Fournier)
5. Aspects of soil erosion in Israel - national report (by R. Keren and B. Yaron)
6. National report of Italy (by F. Mancini)
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9. Rapport de consultation - cas de la zone côtière du Maroc (par A. El Ibrahimi)
10. Rapport national tunisien (par A. Souissi)
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12. National report of Yugoslavia (by B. Milos)
13. Synthesis of national reports (by M. Ciric)*
14. Notes of the Working Meeting on the Priority Action entitled "Promotion of Soil Protection as the Essential Component of the Environmental Protection in Mediterranean Coastal Zones"*
15. The Israeli concept for runoff and erosion control in semi-arid and arid zones in Mediterranean basin (by M. Agassi, Y. Benyamini, J. Morin, S. Marish and E. Hankin)
16. Integrated Approach for the Management of Watersheds in Italy (by F. Mancini and S. Grazi)
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18. Etude portant sur la protection des terres agricoles dans les zones côtières contre l'utilisation non agricole - Tunisie (par H. Baccar et M. Hentati)
19. The case study of Turkey (by M. Kilinç and T. Celikkol)
20. Yugoslav case study: Protection of agricultural land from non-agricultural uses in the Adriatic coastal zone (by M. Janıc)
21. Synthesis report of the case studies (by M. Ciric)*
22. Draft Joint Project Proposal "Inventory and Network of Erosion Measurement in the Mediterranean for Environmentally-sound Land Management"
23. Soil Conservation and the Mediterranean Region - New Directions
24. Remote Sensing and Soil Erosion (by J.A. Howard)

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* in English and French

* en français et en anglais

PUBLICATIONS IN THE MAP TECHNICAL REPORTS SERIES

No. 1 UNEP/IOC/WMO: Baseline studies and monitoring of oil and petroleum hydrocarbons in marine waters (MED POL I). MAP Technical Reports Series No. 1. UNEP, Athens 1986.

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No. 5 UNEP/FAO: Research on the effects of pollutants on marine communities and ecosystems (MED POL V). MAP Technical Reports Series No. 5. UNEP, Athens 1986.

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No. 7 UNEP/WHO: Coastal water quality control (MED POL VII). MAP Technical Reports Series No. 7. UNEP, Athens 1986.

No. 8 UNEP/IAEA/IOC: Biogeochemical studies of selected pollutants in the open waters of the Mediterranean (MED POL VIII). MAP Technical Reports Series No. 8. UNEP, Athens 1986.

No. 8 Add. UNEP: Biogeochemical studies of selected pollutants in the open waters of the Mediterranean (MED POL VIII). Addendum, Greek Oceanographic Cruise 1980. MAP Technical Reports Series No. 8, Addendum. UNEP, Athens 1986.

No. 9 UNEP: Co-ordinated mediterranean pollution monitoring and research programme (MED POL - PHASE I). Final report. 1975 - 1980. MAP Technical Reports Series No. 9. UNEP, Athens, 1986.

No.10 UNEP: Research on the toxicity, persistence, bioaccumulation, carcinogenicity and mutagenicity of selected substances (Activity G). Final reports on projects dealing with toxicity (1983-85). MAP Technical Reports Series No. 10. UNEP, Athens, 1987.

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No.13 UNEP: Specific topics related to water resources development of large Mediterranean islands. Documents produced in the second phase of the Priority Action (1985-1986). MAP Technical Reports Series No. 13. UNEP, Priority Actions Programme, Regional Activity Centre, Split, 1987.

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No.15 UNEP: Environmental aspects of aquaculture development in the Mediterranean region. Documents produced in the period 1985-1987. MAP Technical Reports Series No. 15. UNEP, Priority Actions Programme, Regional Activity Centre, Split, 1987.

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No. 5 PNUE/FAO: Recherche sur les effets des polluants sur les communautés et écosystèmes marins (MED POL V). MAP Technical Reports Series No. 5. UNEP, Athens 1986.

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No. 7 PNUE/OMS: Contrôle de la qualité des eaux côtières (MED POL VII). MAP Technical Reports Series No. 7. UNEP, Athens 1986.

No. 8 PNUE/AIEA/COI: Etudes biogéochimiques de certains polluants au large de la Méditerranée (MED POL VIII). MAP Technical Reports Series No. 8. UNEP, Athens 1986.

No. 8 Add. PNUE: Etudes biogéochimiques de certains polluants au large de la Méditerranée (MED POL VIII). Addendum, Croisière Océanograhique de la Grèce 1980. MAP Technical Reports Series No. 8, Addendum. UNEP, Athens 1986.

No. 9 PNUE: Programme coordonné de surveillance continue et de recherche en matière de pollution dans la Méditerranée (MED POL - PHASE I). Rapport final. 1975 - 1980. MAP Technical Reports Series No. 9. UNEP, Athens 1986.

No.10 PNUE: Recherches sur la toxicité, la persistance, la bioaccumulation, la cancerogenicité et la mutagenicité des certaines substances (Activité G). Rapports finaux sur les projets ayant trait à la toxicité (1983-85). MAP Technical Reports Series No. 10. UNEP, Athens, 1987.

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No.14 PNUE: L'expérience des villes historiques de la Méditerranée dans le processus integré de rehabilitation du patrimoine urbain et architectural. Documents établis lors de la seconde phase de l'Action prioritaire (1986). MAP Technical Reports Series No. 14. UNEP, Priority Actions Programme, Regional Activity Centre, Split, 1987

No.15 PNUE: Aspects environnementaux du développement de l'aquaculture dans la région méditerranéenne. Documents établis pendant la période 1985-1987. MAP Technical Reports Series No. 15. UNEP, Priority Actions Programme, Regional Activity Centre, Split, 1987.

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