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Dryland Management: The "Desertification" Problem

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ABSTRACT

This paper argues that the problem of desertification has been poorly characterized in several ways by public statements, books, magazines and sometimes scientific articles. First, the impression has been conveyed that the extent of the problem of desertification is well known, when in fact the evidence is extraordinarily scanty. Second, the degree to which there is professional agreement among scientists and practitioners on the extent, causes and solutions has been overestimated. Third, the extent of desertification as an irreversible state has probably been exaggerated, although it is correct to classify it as a serious problem. Fourth, the image created has too often been of inexorably advancing sands, as opposed to more subtle, more complex, pulsating deteriorations, sometimes with reversals, but at least, with substantial periodic remissions, radiating out from centers of excessive population pressure. Fifth, the availability of profitable technologies to combat the problem has been overestimated because the gap between what is socially profitable and what is perceived as privately profitable has been underestimated.

The paper offers a number of strategy priorities which respond to this somewhat different characterization of the problem. The most important of these is a call for more measurement of the extent of the problem, deeper analysis of the causes and increased focus on the design of technologies to be appropriate for the land/labor ratio in the area and the timing of the evolution of the farming system. The paper concludes with some operational implications for the Bank. The paper has a global focus but a substantial Africa-related content.

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I. INTRODUCTION

1. This paper argues that the problem of desertification has been poorly characterized by public statements, books, magazines and sometimes scientific articles. It has been poorly characterized in five ways. First, the impression has been conveyed that the extent of the problem of desertification is well known, when in fact the evidence is extraordinarily scanty. Second, the degree to which there is professional agreement among scientists and practitioners on the extent, causes and solutions has been overestimated. Third, the extent of desertification as an irreversible state has probably been exaggerated, although it is correct to classify it as a serious problem. Fourth, the image created has too often been of inexorably advancing sands, as opposed to more subtle, more complex, pulsating deteriorations, sometimes with reversals, but at least, with substantial periodic remissions, radiating out from centers of excessive population pressure. Fifth, the availability of profitable technologies to combat the problem has been overestimated because the gap between what is socially profitable and what is perceived as privately profitable has been underestimated.

2. In the last sections of the paper we offer a number of strategy priorities for borrowers and for the Bank which respond to this somewhat different characterization of the problem. The most important of these is a call for more measurement of the extent of the problem, deeper analysis of the causes and increased focus on the design of technologies to be appropriate for the land/labor ratio in the area and the timing of the evolution of the farming system. The reader should not look for new technical or policy solutions in this paper. Such things are seldom uncovered by "think-piece" overviews of this sort. They are found in the field by search and evaluation and are usually country-specific, if not village-specific, in nature. What is offered here is a revisit to some fundamental issues and a broad sketch of a stance taken on desertification which we believe is somewhat different from the conventional stance. It represents a review of the evidence and a declaration of a position which some readers may feel they have visited before but which we believe it is useful to establish, and, indeed, to re-establish from time to time as understanding evolves.

A Definition of "Desertification"

3. Some of the fault for the misrepresentation of the problem of desertification, and undoubtedly it <u>is</u> a global problem, lies with the term itself. Paradoxically, the term desertification itself has become, in a sense, desertified. It is a term that served a purpose in raising public awareness, but it now cloaks the problem in a disguise that obscures its true shape. The two most serious problems are first, that everyone defines

desertification differently with respect to several important characteristics and, second, that the commonly used phrase "desertification control" directs attention negatively at stopping damage rather than positively at improving land management. The difference is more than semantic.

4. To cover our own reluctant use of the word desertification, and to start to uncover the issues, we offer a definition.

> "Desertification is a process of sustained land (soil and vegetation) degradation in arid, semi-arid and dry sub-humid areas, caused at least partly by man. It reduces productive potential to an extent which can neither be readily reversed by removing the cause nor easily reclaimed without substantial investment."

5. This definition accepts both soil and vegetation deterioration as being potentially desertification. In order to allow a dryland focus it excludes areas with higher rainfall than the dry sub-humid zone as defined in the FAO/IIASA (1986) Study of Carrying Capacities. (The dry sub-humid zone as defined in that study has 600 to 1,200 mm rainfall and a maximum of 180 days growing season.) The definition insists that there must be some man-induced element in the changes. It characterizes the change as being a sustained change so that shorter-term fluctuations are excluded and it attempts to loosely define irreversibility in terms of ease of recovery of productive potential. Clearly the loose terms "readily reversed by removing the cause" and "easily reclaimed without substantial capital investment" present difficulties; on the other hand, defining them more tightly also presents difficulties. We would consider a 10-year natural recovery of productive potential, or an investment of a substantial capital as opposed to a recurrent nature, to be the dividing lines between effectively reversible and irreversible situations. The intent of the "substantial capital investment" criteria is to exclude those situations, encountered, for example, in ranch management, where intermittent investments in such things as bush control would be considered "normal," and more or less recurrent, expenditures.

6. The definition offered here is consistent with, but more explicit than, a shorter alternative which is: "Difficult to reverse land degradation in dry areas caused partly by man." Indeed, if it were not for the penetration of the word desertification in the literature we would have preferred to ignore it entirely and stick to the words dryland degradation. For a useful review of the enormous range of alternative concepts of desertification, see Glantz and Orlovsky (1986).

7. Interestingly the term desertification was first used by Aubreville (1949) to refer to areas excluded by most current definitions. He noted "Ce sont de vrais deserts que naissant aujourd'hui, sous nos yeux, dans des pays ou il tombe cependant annuellement de 700 a plus de

1,500 de pluies" (These are real deserts that are being born today, under our very eyes, in regions where the annual rainfall is from 700 mm to 1,500 mm) (quoted in Glantz and Orlovsky, 1986). In this paper, we exclude the higher rainfall end of this range, not because we do not consider degradation problems important in those areas, but because we prefer to have them treated under the broad humid and sub-humid areas topic of watershed management.

8. In defining the problem in a particular situation on the ground, understanding the historical, biological and social evolution of the system is essential (Gritzner pers. comm.). One example from a predominantly farm systems perspective is the sequence identified by Newcombe (1984) in Ethiopia as having five phases:

Phase 1. The rate of wood harvesting exceeds the annual increment.

Phase 2. Wood becomes scarce, crop residue and dung are increasingly used for fuel, nutrient recycling is therefore interrupted, soil conditions deteriorate.

Phase 3. Trees are virtually gone, crop residue and dung become the predominant fuel and now sell for cash, soil deterioration accelerates, yields decline.

Phase 4. Dung becomes the only source of fuel, crop residues now go entirely to feed livestock, soil erosion is dramatic.

Phase 5. Total collapse, usually triggered by a dry period, emigration of people. (Some, probably most, specialists would argue that there are few places that have reached this point and that even when it appears to have been reached it is often less permanent than it appears.)

9. Other sequences, moving towards either bare ground or dense unpalatable bush, can be described for range areas.

10. In the following sections we investigate, first, the evidence for the extent and the type of the desertification problem, the two being difficult to separate, second, the availability of technological solutions, and, third, what this diagnosis means for strategies of dryland management.

II. THE EXTENT AND TYPE OF THE DESERTIFICATION PROBLEM

11. The areas of the world which are particularly threatened by desertification are generally around the perimeters of true- or near-deserts. Locations of main concern are: Southern Africa, parts of the Saudi Arabia peninsula and the Middle East, Rajasthan, areas around the

Gobi Desert, Southern USSR, Australia, USA and Mexico, North-east Brazil and the western side of South America. However, contrary to popular belief, the extent of desertification is not at all well known. There is extremely little scientific evidence based on field research or remote sensing for the many statements on the global extent of the problem. This does not mean desertification is not happening or that it is not a serious problem. It simply means we do not know. For example, soil erosion in dry areas is a main element of desertification and El-Swaify et al (1982) notes in a comprehensive study of soil erosion in developing countries that "..... there is little or no documentation of the extent, impact or causes of erosion ....."

12. The evidence for desertification that is most often quoted and requoted publicly comes mainly from only two sources, both of which have been quite seriously questioned. The first is a global UNEP study (summarized in Mabbutt, 1984), the second an investigation in 1975 in Sudan by Lamprey.

13. Beyond these two most frequently quoted studies there are seven other categories of study that have contributed to measuring the problem: (i) The Normalized Difference Vegetation Index work of Tucker using NOAA data now covering 1981-1987 for the Sahel. (ii) A few regional studies relying on remote sensing, e.g., USAID's Sahel-Sudano Desertification Study (1978). (iii) A number of quite detailed smaller country or district studies with a substantial amount of ground-truthing, some of it rather qualitative, e.g., Coquimbo, Chile. (iv) Soil studies such as the FAO/UNESCO Soil Map of the world, (not useful as a direct indicator of desertification and of limited operational value, but possibly of some help in establishing and monitoring upper bounds to the extent of severe global soil degradation) and perhaps one should include here the use of the Universal Soil Loss Equation as a model. (v) Isolated data quotes and anecdotal evidence from field visits. (Whether this should be termed "evidence" is very questionable. Non-random one-off flying visits to climatically highly variable arid areas which are not well known to the observer, with no follow up, and often selected for having a severe problem, are likely to be biased sources of information.) (vi) There is one fascinating and meticulous "before and after" ground (i.e., snapshots) photographic study in Africa by Shantz and Turner (1958), spanning a 30-year period. This is a neglected qualitative technique which, with comprehensive reviews of old photographic sources, and modern day follow-up could be highly productive. We review these various sources of evidence in the following sections (except Shantz and Turner because it is not recent).

A. <u>The UNEP Study (see Mabbutt 1984)</u>.

14. This study and the earlier UNCOD baseline assessment in 1977 is a main source of the often quoted estimate that approximately 20 million hectares annually are reduced to zero or negative economic productivity (an obscure concept), and six million hectares become wasteland and that the number of people inhabiting land being desertified has increased by 35%

since 1977. The study was based mainly on: (i) the 1982 questionnaire of 27 pages (see UNEP/ESCAP 1983 for a copy of the questionnaire); (ii) regional assessments by UNSO and regional UN commissions; and (iii) updates of case studies. The study does carry the caveat that the information provided from the questionnaire was commonly patchy and often unsatisfactory, but there is some evidence that this is an understatement. A demographer (Caldwell, 1984) who utilized what seems to be the easiest part of the questionnaire, the population tables, noted:

> "It was not clear whether the land classification itself could change between these years (presumably the only real measure of desertification) or whether the aim was merely to measure the changing balance of population in zones fixed at least for this period. Even the latter objective defeated most officials completing the table, and for the arid lands very little of value can be obtained from the returns."

This UNEP study[1] finds that, within the dryland areas 80% of the rangeland, 60% of the rainfed cropland and 30% of the irrigated land are at least "moderately desertified"[2] (see Table 1).

15. Just how government staff completing the questionnaire interpreted "moderately desertified" and "severely desertified" is unclear. Particularly since in Africa they were completing it in many cases at the height of a drought. For rangelands, for example, the definition for moderately desertified was "significant reduction in cover and deterioration in composition of pastures; locally severely eroded; would respond to management supported by improvements and conservation measures. Loss of carrying capacity up to 25% of earlier carrying capacity." It is

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1/ Using the definition: "Desertification is the diminution or destruction of the biological potential of the land, and can lead ultimately to desert-like conditions." (The words "biological potential of the" are omitted from the Mabbutt 1984 paper).

2/ We have come across a number of misquotes of the study. For example in one study the percentages of degraded rangelands categorized in the study as being "moderately desertified" become described as "seriously degraded." Another reference takes the same estimates for the amount of moderately desertified land and describes it as exhibiting a 25% loss of potential productivity when in fact the definition referred to up to 25% loss of productivity. Similarly, for severely desertified land, the same reference describes it as exhibiting a 50% loss of potential productivity when in fact the definition referred to between 25% and 50% loss of productivity. Generally, the use of this data seems to have been very casual.

not clear whether these sentences are implicitly connected by an "and" or an "or." Nor is it clear what the bottom end of the "up to 25%" range carrying capacity loss was. But surely at the start of the eighties in Africa there were no areas not suffering from significant reduction in cover compared to the 50's and 60's. (See the rainfall pattern in Chart 1.)

16. The point is not to be critical of the questionnaire or the study; given the lack of measurements in the field and the public and political demands for some quantification what else can be done? The point is to emphasize that the results, which are by far the most widely quoted evidence on the extent of desertification, have an extraordinarily shaky basis and have clearly been enormously influenced in Africa, by being completed after a long and exceptionally dry period.

17. More generally, our review suggests that a healthy skepticism of quoted data on desertification is warranted. For example a reader might be forgiven for interpreting the often quoted statement that "the number of people who inhabited lands undergoing desertification (in 1984) had increased by 35% over the number presented to UNCOD in 1977" as meaning that 35% more people were suffering from the effects of desertification in 1984 than in 1977. The true picture is very different because the study universe from which the affected people were drawn changed substantially between 1977 and 1984. The sub-humid areas of the world were excluded in 1977 and included in 1984, so one would expect a greatly increased affected population. The definition of desertification was also somewhat different. The quoted percentage is therefore very misleading, unless the number of people suffering from desertification in the sub-humid zones in 1977 was zero (hardly likely since even the coiner of the term desertification, back in 1949, first used it in reference to these areas.)

B. <u>The 1975 Lamprey Study in Sudan</u>

18. This study appears to be the main source of the other most widely quoted evidence of desertification, that the Sahara desert is advancing south at 5.5 km/yr. This study has been disputed recently by what seems to be a well conducted remote sensing and ground study of a transect in the same area by Hellden (1984) who finds:

> "There was no creation of long lasting desert-like conditions during the 1962-1979 period in the area corresponding to the magnitude described by many authors and commonly accepted by the Sudanese Government and international aid organizations ..... The impact of the Sahelian drought was short lasting followed by a fast land production recovery. If desertification takes place in the transect it is not a fast process. Its major impact is assumed to be a slow expansion of unpalatable species and annuals at the cost of palatable species and perennials accompanied by a reduction of the fuelwood resources available."

19. Even this last assumption is somewhat discounted by the findings of Olsson (1984) in the same area, who notes that:

> " ..... no woody species has been eradicated from the area, no ecological zones have shifted southwards and the boundaries between different vegetation associations appear to be the same now as they were 80 years ago. A gradual move toward a more useless woody species composition can be traced in limited areas under a heavy population pressure. On the other hand, there are also examples of soil and vegetation recovery within the area which clearly demonstrates the dynamics of the countryside."

20. Again, we emphasize that localized studies of this sort cannot demonstrate that globally land degradation or advancing deserts is not a serious problem, but they contribute small pieces to a scattered patchwork of evidence that may be starting to build up into a more balanced global picture, a picture much more complex and much more mixed than is implied in the many rather poorly substantiated litanies of disaster on desertification.

C. Continent-wide Remote Sensing Evidence Using the Normalized Difference Vegetation Index from National Oceanographic Atmospheric Administration (NOAA)

21. This NOAA polar-orbiting meteorological satellite is very useful for monitoring massive vegetation changes. However it does have several limitations: first, without ground follow-up, it cannot distinguish between desirable and undesirable plant communities which may exhibit similar color; second, it has very low resolution compared to Landsat and Spot; third, along with other satellite-based technology, it is still of somewhat limited value because of the short time period (1981 to 1988) of coverage.

22. Using this NOAA imagery, Dregne and Tucker (1988) report a comparison between the 1984 and 1985 Normalized Difference Vegetation Index (NDVI) on the south side of the Sahara. The year 1984 was one of the driest years in three decades, 1985 was the wettest since 1981. The imagery shows that the vegetation boundary shifted generally north, for example, about 200 km in the Sudan/Chad border area, but regional differences in this shift were considerable. The authors point out that since oscillations of that magnitude appear normal, the identification of a permanent shift of five to six km per year (a figure often quoted for desert boundary shift, probably based on Lamprey (1975)) would take about 30 to 40 years of observation before one could conclude that the shift was permanent. The long-term and continent-wide nature of the monitoring needed (both ground and remote) raises questions about how it should be paid for and organized to ensure efficiency and permanence.

D. Regional Case Studies Using Remote Sensing

23. One of the main examples of this type of study is USAID's 1978 Sahel-Sudano Desertification Study which evaluated the usefulness of Landsat for monitoring the effects of desertification in parts of Mauritania, Mali and Senegal. While this study shows that remote sensing can find, for example, vegetation in the higher rainfall year of 1976 where it was absent in 1972 and 1977, and can see the extent of flooding and fire burns, sand dune encroachment and salinization, it presents little evidence of anything other than small, short-term, localized examples of soil and vegetation changes which may or may not be difficult to reverse. Thus, while interesting from a methodological point of view, the study is of limited value for assessing the extent of the problem at a national or regional level.

E. Country Studies Using a Range of Techniques

24. There are a number of country studies of varying quality. We briefly outline five of the most useful (covering four continents) which we believe are representative:

i) India

25. In India, the Central Arid Zone Research Institute (CAZRI) quantitatively monitors desertification quite intensively using a range of techniques. They have found evidence of localized outward spreading degradation but little evidence of advancing sands. Using remote sensing, they found that there is no evidence to suggest that the desert in Rajasthan is spreading towards the Delhi-Mathura-Agra Region. However, they did find evidence that over the 18-year period 1958-1976 approximately 8% of the Luni Block suffered accentuation of sand undulation, approximately 3% of the area suffered deflation, and approximately 8% of the area exhibited an increase of sand on fence line hummocks. (The first and last figures are predominantly building of sand on sand.) In aggregate 4.35% of Western Rajasthan had been effected by the process of desertification. These are quite serious changes which call for continued monitoring and serious attention.

ii) Chile

26. In Chile a very detailed study (UNESCO, 1980) in the region of Coquimbo, gives an excellent but largely qualitative assessment of the seriously retrogressive successional vegetation changes that have occurred in each zone of the study transect. Changes have led in some cases to abandoned farm lands, in other cases to dense bush and in other cases to invasion by columnar cactus. While climax plant associations are often not the most desirable associations for productivity, the changes documented in Coquimbo are clear evidence of land degradation, much of it well beyond the the short-term irreversible element of our desertification definition. This does seem to be a case of serious, largely irreversible change.

iii) Niger

27. The Niger Case Study (UNESCO, 1980) is by no means all a litany of degradation at least in the early '70s. One study cited, the most quantitative and detailed by Peyre de Fabreques (1971) based on transects taken over several years, notes that stocking rates double or triple those considered appropriate did not create irreversible or inevitable deterioration in the vegetation. The author noted that "..... from an agrostological point of view, it can be said that the present composition of the plant cover, established on the basis of average observations over several years, corresponds on the whole to a stabilized sub-climax. Its forage value is practically identical to that of ungrazed pasture."

28. However, a later, more qualitative assessment during the drought in the same area (Bondell, 1972) was less optimistic. He describes a "barren area, compacted and strewn with dead trees." A repeat study now of these same areas would be valuable.

iv) Sudan

29. Sudan has been studied quite widely (see Pearce, 1987 for a review). There has been a widespread loss of tree and bush cover in the mechanized farming areas. Whether all this should be defined as desertification is less clear since the heavy flat clay plains do not appear, on a large scale, to suffer from a level of water or wind erosion that seriously reduces productivity. However, the loss of tree cover in those areas has put increased pressure on other areas which are more fragile. Much of the problem in Sudan can be attributed to inappropriate policies. Declining crop yields in Sudan have been quoted in a number of studies and in government and donor documents as evidence of desertification. While it seems clear that Sudan has quite serious problems in certain areas, it is by no means clear that the aggregate data on declining crop yields are indicative of degradation. One should expect declining national average yields in Sudan (Swift pers. comm.) because over the last two decades the extension of agriculture has been towards the drier north while the mean rainfall isohyets, at least in the short term, have been moving south. Olsson (1983), for example, found that 85% of the variation in millet yields in Northern Kordafan between 1952 and 1980 was explained by rainfall.

v) Australia

30. Stanley (1982) finds that "... the best available estimates suggest that approximately 35% of Australia's arid lands have been degraded. The general trend in condition has probably approached a steady-state, however while some rangelands may be improving, other areas are deteriorating and are cause for concern."

31. Condon (1982) notes with respect to western New South Wales, one of the better areas: "Since the middle 1970's,, it has become obvious that

there has been a remarkable recovery throughout the pastoral zone of western New South Wales ..... Even the sloping scalds of the frequent clay lunettes on the western end of the Riverina plain, for which the prospects of recovery were regarded as more hopeless than hopeless, have recovered over more than half of the formerly eroded surface."

32. He attributes the improvement to a number of factors, including improved rainfall, disappearance of the rabbit, closer settlement giving smaller numbers of sheep converging on one woolshed, the 1950's wool boom providing money for more water points and fence development and thus fewer animals converging on one point, road transport to move stock out of drought areas fast, financial drought relief resources (concessional restocking loans, etc.), increased grazier awareness of overstocking due to the smaller holdings, and increased security of tenure making for easier borrowing.

33. Other researchers in Australia (e.g., Harrington, 1982) seem to suggest that degradation in Australia is generally less severe than elsewhere in the world, although this does not mean there are not some quite serious land management problems in Australia.

F. Soil Surveys and the Soil Loss Equation

34. Soil Surveys. One possible source of supporting evidence on the extent of desertification is the Pedogenic Indicators derived from the FAO/UNESCO Soil Map of the World used in the Desertification Hazards Map of Africa. These give no direct evidence of the extent of man-induced desertified states, or of the rate of the desertification process generally, but, because they measure the extent of certain defined soil conditions which may result from poor land management, they may be useful in some locations for at least setting upper bounds on the extent of man-induced changes. The survey identifies areas of salinization, soil cementation, wind driven ablation and accumulation, water erosion, aridic conditions and low temperature regimes (see Table 2).

35. All of these land and soil characteristics can occur without man's intervention. However, it is also true, and more significant for our purposes, that long-term and serious mismanagement of land would almost certainly eventually result in one of the first four soil conditions listed. However, the percentage land areas in the table need careful interpretation because the maps indicate that some categories overlap substantially and that much of the wind ablation occurs in areas of limited interest for human settlement, e.g., in true deserts. The percentages on cementation and water erosion are probably the most revealing.

36. Soil Loss Equation. The examples given so far have discussed the presence or absence of direct evidence on the extent of desertification. What about modelling the physical processes? It is known from the research which developed the Universal Soil Loss Equation, and regionally applicable

adaptations of that equation in Africa (Elwell, 1978) and elsewhere, that certain levels of rainfall intensity, slope, vegetation cover and soil type give certain levels of soil loss in plot experiments. Furthermore, it is known that the level of soil loss indicated by these soil loss equations for areas of reduced ground cover often are rates greater than the natural processes of soil creation. Thus these soil loss equations seem to indicate that irreversible degradation must be occurring. Clearly one cannot dismiss this. However, in the practical application of the theory two additional aspect must be considered. First, that soil loss equations are crude proxies which do not in fact model the actual physical processes and their interactions and therefore have limited value for generalization (Hillel pers. comm.). Second, that even if the soil loss from the location of particle dislodgement were adequately explained by these equations, the destination of the resulting sedimentation and the time frames of its relocation are also important (Mahmood, 1986). Soil loss, while usually bad, is not invariably so. Sometimes, it has been used deliberately, for example, in North Africa, to fill depressions with greater depths of deposits for agriculture. The aggregate irreversible damage over a period depends also on where the soil moves to, its rate of passage down the watershed, which in many cases is measured over decades, even centuries, the changing rate of soil loss over time and the changing resilience over time of the land that remains. Thus, soil loss equation calculations from a site can only be indicative and need verification on the ground.

G. Isolated Data and Anecdotal Evidence

37. There is a considerable quantity of isolated data and anecdotal evidence related to desertification. It is difficult to know how to use this in reviewing the evidence. Much of it is pessimistic; some is more optimistic. One reference on the pessimistic side, and perhaps the most widely quoted anecdote related to irreversibility (Le Houerou, 1975), is that in southern Tunisia the tracks left by tanks during the battle of Ksar Rhilane in 1943 were still visible 30 years later. One on the optimistic side is from Haldeman (1987) who writes with respect to recovery of rangeland in Kenya, ".... my first impression of Kaputiei section in late 1968 bore no relationship to the stories I soon heard and descriptions I later read of the tragedy that had occurred about seven years before."

III. DO WE HAVE THE TECHNOLOGIES?

38. There is considerable disagreement between specialists on the availability of technologies. For example in the same article in one newspaper (Christian Science Monitor 5/19/88) one specialist is quoted as saying, "The problem is political and socio-economic. It is not technical." Another is quoted as saying, "(there are) no instant solutions; no technical panaceas." The more common view is that we do have the technologies (UNEP, 1987; Lal, 1987, and others) and all that is needed is the funds and the national and donor agency commitment to use those

technologies. This paper disputes that view, or at least disputes the definition of technology which is implied in that view. This paper defines an existing technology as follows: "An existing technology is one that is perceived to be feasible and worthwhile by a significant proportion of farmers or pastoralists in the area or is sufficiently close to being so perceived that readily achievable modifications of incentives (e.g., sustainable levels of subsidy) can make it so." In other words, by the definition used in this paper, the often read statement that an intervention was "technically successful but uneconomic" is a contradiction in terms (avoiding, for simplification, the complicating differences between financial and economic profitability.)

39. We believe that, while there are certainly some existing technologies that fall under the above definition, they are considerably fewer than is commonly believed. This is partly because farmers and pastoralists demand very high and immediate returns and/or lower risk to trigger adoption on a large scale, while sustainability, almost by definition, demands a longer-term view. This gap between what is sustainable and what is privately profitable and low risk needs to be closed. Indeed, it already has been for a limited number of technologies in certain areas, e.g., the vetiver grass moisture conservation system, the planting of certain tree species for browse, fuelwood or windbreaks in some locations. But we believe such technologies are not as widely available and profitable as is often claimed. For example, in Sudan, although the common perception by advisers is that mechanized farmers would benefit greatly from planting windbreaks, it is by no means obvious, when farm models are calculated, that the benefits outweigh the costs. Often there is a lack of technologies or investment opportunities that do not require high labor inputs. In most areas a few individual farm families have indeed adopted one or two new practices and building on this is clearly the way to go. The problem is first, that these have required considerable local adaptation and heavy extension support which makes it a slow and costly process, and second, the adopters frequently have an advantage in terms of labor availability, usually because of wealth in one form or another. The potential for trickle down seems therefore in doubt. For example, seedling survival in tree planting is often related to frequency of early watering yet in many dry areas it is only the wealthy who can afford to water at all.

40. We expand on this view that technologies are rather limited by taking the three most fundamental technological questions in dry areas. The first is the question of whether we have a widely applicable improved system for sustaining soil fertility for cropping in high population density dry areas. The second is whether we have a widely applicable improved technology or system for better managing livestock on open range forage in pastoral areas. The third is whether farm forestry represents a widely available technology in dry areas. This has linkages to both the fertility and the livestock issues. We believe that as of 1987 the answer to these three questions generally must be no, although areas of 200 mm to 400 mm rainfall are very different from areas of 600 mm to 800 mm and the availability of technologies does increase as the rainfall rises.

41. With respect to dryland cropping technologies, there are a few scattered successes. Perhaps the most exciting, with potential for a significant global impact, is the vetiver grass (vetiveria zizanoides) vegetative moisture conservation system which is taking off in India as a replacement for each bunding and which utilizes a plant with an exceptionally wide climatic range. However, success on the nutrient front is more elusive. The continuing decline in the farmgate price of crop output relative to the farmgate cost of fertilizer input (Carr pers. comm.), and the very modest yield responses to fertilizer associated with low rainfall and poorly responsive indigenous cultivars which put much of the nutrient uptake into stalks, mean that, in these areas, researchers have to find ways to substantially increase production without the benefit of fertilizers which have been the engine of yield increases in the rest of the world. Alternatively, substantial levels of fertilizer subsidies have to be provided, which, in countries relying for income predominantly on dryland agriculture, is simply taking money out of one pocket and putting in the other.

42. "Nutrient pumping" using trees tends to be offered as the soil fertility panacea for cropping situations. This indeed does seem the direction to look, but field experience with adoption in arid and semi-arid areas is so far rather mixed. The Chad Acacia albida planting program (Kirmse and Norton, 1984) presents one example of the difficulty. The Acacia (Faidherbia) albida has many excellent qualities yet this particular project in Chad still has relied on quite costly food incentive payments to buy farmers' interest and participation. More recently other Acacia albida programs have reported less need for subsidy, so there is some promise. But in Burkina Faso, the Yatenga OXFAM project, after some years of rather unpromising experience attempting to combine water harvesting with tree growing, swung towards the production of annual crops. These examples highlight the complexity of achieving the tree belts across Africa dreamed of by planners for the last 60 years. The germs of a number of solutions are there but they are not emerging quickly on the ground and, perhaps more important from the cost side, they do not follow a regular predictable pattern. Ellis (1987) notes for the National Geographic:

> "In more than two months of travelling the Sahel I did not find a single major success story. Only reforestation in the Majjia Valley (Niger) comes close."

This last impression is perhaps a somewhat bleaker picture than is warranted. Yet it is true that successes are few and far between, hence the frequent quoting in the literature of the same cases; e.g., Majjia in Niger (which still raises some troublesome questions), Guesselbodi in Niger, Yatenga in Burkina Faso. It is also true, unfortunately, that what seem successes at first sight often reveal themselves to be severely tarnished as replicable pieces on close examination.

43. A review of the research literature reveals one of the major problems. There is plenty of quantification of what, technically, can be achieved on research plots and there is widespread description of why certain systems should be productive (e.g., the exploiting of larger soil volumes by mixed species, etc.), but in spite of the increased focus in recent years on farm systems studies there is still seldom any calculation of financial returns, cash flow in worst years, incremental labor requirements, or discounted cash flows exploring the impact of farmers short time-preference. Often, nothing more than the back of an envelope is needed to get a fair idea of what a farm family will think of the profitability of an innovation, yet such calculations are seldom done.

44. The prevention strategy of halting the desertification problem seems to have diverted attention from the more promising strategy of simply developing profitable land management systems in dry areas, and this prevention strategy seems in turn to have diverted attention from profitability. Past studies and experience has shown that farmers and pastoralists responses are rather well explained by perceptions of profitability and worst-year outcomes.

45. The picture on pastoral livestock systems is similar. The literature is filled with bold proposals for "better range management." Yet, there is wide disagreement between specialists on the extent to which readily applicable techniques for better range management really exist. The reality seems to be that in many of these areas very little is known about how to manage range better than it is being managed now, beyond the often unhelpful proposals to reduce stocking rates and close off areas for recovery. Research results in dry areas do not clearly show that rotational grazing patterns are better than fixed stocking, and even closing off areas can go wrong unless properly managed. For example, Conant (1982) found that the Simbol area in a Pokot district in Kenya, which had been effectively closed off due to armed raiding, became impenetrable bush, effectively removing it from human use, at least in the short to medium term. There is some promise in multi-species wildlife utilization, both for meat and (Muir pers. comm.) for high value hunting, but a number of associated management, social and equity issues to be resolved.

46. Even in developed countries such as Australia very little is known about range management in arid and semi-arid areas. For example, Harrington (1982) notes with respect to Australia:

> "At present ecological understanding is so poor that nothing better than conservative stocking, with particular regard to destocking in dry times before the soil is exposed to erosion agents, can be suggested. This option is not available to most of the world's arid zones as the people have not got the resources or government support to survive bad times by selling off their stock."

47. One can probably go further and say that the lack of rapid and unambiguous knowledge feedback (Harrington, 1982) in arid and semi-arid zones due to the highly variable rainfall and the extreme infrequency of similar cycles of climatic events, even makes research for developing improved techniques very difficult. It certainly makes the building up of management experience very difficult, except as pastoralists have done it, accumulating the experience passed down across generations. An Australian farmer once summed up the producers' dilemma in these risky areas rather well: "You can learn enough in one year to make a fool of yourself the next."

48. Again, this does not mean there is nothing to offer on technology in these areas. Such small actions as improving herd conversion efficiency by providing better calf management through calf camps linked to some forage grown with water harvesting, and other little things can add up to a modest pilot program, but they are unlikely to achieve substantial gains like doubling carrying capacity in the next 20 years. For example, following the experience and experimentation of the first project, the World Bank's Second Central Rangelands Project in Somalia hopes only for some quite small gains in productivity and land protection. Once again, as with crops, the economics cannot be ignored in developing technologies. At the stocking rate and offtake rates of these areas, even with optimistic assumptions about incremental gains, only extremely small investments of, at the most, a few dollars per hectare can be justified. In open access rangeland areas the question of what is a profitable innovation is complicated by the land tenure system. Certain range management practices which might be seen as profitable by a ranch owner may be less interesting to individual members of a large pastoral group, although cooperation may not be as difficult to achieve as the somewhat overworked "tragedy of the commons" thesis implies.

49. The third technology area is the area of farm forestry. This is an area of particular concern because the major cause of degradation in dry areas is that, while often food production, or at least food supply, has kept pace with the growing population, energy supply for cooking and fodder for livestock has not (Groenewold, FAO, pers. comm.). Here the picture is not all bleak. There have been some successful initiatives in a number of countries including India and a few in Africa in areas subject to desertification, particularly in the higher rainfall dryland areas. But this technology is not, in the drier areas, the widespread panacea that project proposals often imply. The difficulty is that we do not yet know how to encourage spontaneous tree planting in dry areas without subsidies on a large enough scale to give substantial environmental benefits before the last tree is cut, although smaller-scale plantings for shade and pole production have been somewhat easier to achieve. Once the last easily accessible and freely available tree is cut experience indicates that planting takes off. The strategy trick with this technology (as indeed with all technologies) is to put the priority on locations where the timing is right with respect to the incentive to plant. But it is precisely this

low-incentive, environmentally damaging, intermediate period which is the problem. It is this period between the point at which cutting rapidly overtakes the Mean Annual Increment of wood produced and the time when the last trees are removed, which is the gap we need to fill from the point of view of halting the onset of irreversible degradation.

50. Since the main constraint is labor and/or cash for planting and protection and often watering, there is considerable potential for lower cost management of natural regeneration and direct seeding of indigenous adapted species. In Sudan estimates suggest that about seven failures of direct seeding still breaks even with the high cost of nursery seedling production. Also children herding domestic stock can plant seeds or throw protective thornbush branches over seedlings, and at Gusselbodi seed planting through termites has helped considerably. With benefits that are uncertain and often modest in the short term the strategy must be towards lower costs than the usual high cost nursery-based approaches.

51. The lack of adoption due to labor constraints can be surprising. For example, even in rapid return annual crop situations, such as in the World Bank funded Baringo Semi-Arid Areas Project in Kenya, demonstrations of water harvesting showed yield increases of 2.3 to 3.4 times for sorghum and 3.5 to 7.7 times for cowpea, yet farmers were still reluctant to adopt it, partly because of increased labor requirements. We can be fairly certain that one day they will adopt this technology, but how soon? Again, the timing has to be right. Extension programs and community participation seem to help to nudge farmers over the threshold when the incentives are almost good enough for spontaneous adoption, but they cannot <u>substitute</u> for adequate incentives.

52. The problem is that it is in these drier drought prone areas that agroforestry is the most difficult and that ecological damage is the most immediately threatening (at least in its more dramatic forms), yet it is precisely in the drier countries with very low GNP that subsidy options or high levels of public expenditure are the least feasible. These are predominantly agricultural economies and the majority cannot very well subsidize itself. A wide spread of location-specific approaches is needed with technologies designed to be appropriate to the soils and climate, appropriate to the land and labor relationships of the system and appropriately timed to the changed circumstances farmers are perceiving.

53. The problem of achieving tree planting and/or lower cost tree regeneration management by farmers themselves is important because for most countries it will not be possible to make a major impact through publicly financed planting programs. Studies by the World Bank (1983) have shown that even with reductions in demand of 20% to 30% through energy saving technologies, considered by some unrealistically high, a 15-fold increase in current public forestry planting rates would be needed to arrive in the year 2000 at a point where the Mean Annual Increment of wood produced would be approximately equal to the rate of harvesting, this with national budgets barely rising, or even falling, in real terms.

54. One of the more sobering indicators of our rather limited progress on technology is the surprisingly modern ring of very old (40 to 100 years) references on dryland areas. In some cases, apart from a few recognizable colonialisms, if one blocked out the dates, they would be hard to distinguish from modern day documents (except that they are noticeably better written!).

IV. THE GLOBAL PICTURE ON DESERTIFICATION

55. The picture that emerges from this review of the evidence is somewhat different from the commonly conveyed picture of inexorable global degradation and advancing sands, caused by mans foolishness, which can readily be solved by about a $5 billion annual investment. Both the problems and the solutions are less clear and less certain, and in many respects, more difficult.

56. First, as we have seen, the evidence is quite mixed, but it is also extremely elusive. As Sandford (1976) has noted, data for one point in time is rare, data for two points in time is even rarer, data for two points at the same position in both the seasonal cycle and the climatic cycle are even rarer still. Furthermore, given the enormous fluctuations and persistence of climatic cycles, the extrapolation of trends from only two points in time is very risky.

57. Second, the perceptions of the causes are often contradictory. For example, as Sandford again has noted, the two conventional wisdoms that on the one hand livestock numbers have been rising for several decades, and on the other hand, the productivity of rangelands has been falling, do not lie at all well together.

58. On the other hand, the fact that the extent and nature of difficult to reverse resource productivity changes have not been well demonstrated empirically does not mean necessarily that these changes have not occurred, because this is also a problem that is extraordinarily difficult to measure. Surely, even if in some places we have mis-specified or exaggerated the problem, the degradation, for example, in Mauritania that has led to a massive urban influx is real and difficult to reverse? Surely the change in the vegetation pattern in Sudan, leading to charcoal being transported into Khartoum from 500 km distance is real and difficult to reverse? Yes, clearly there are serious problems, and because of the high cost of not doing enough or of making the wrong intervention, it would be risky to assume that no news from the evidence is good news. Therefore we do need to continue to take the problem seriously, but in a more thoughtful and scientific manner than we have in the past. This is not predominantly a problem of stopping moving sand dunes and the real causes are not overgrazing, excessive cutting of fuelwood, etc. We have to probe deeper and be more thoughtful in our responses to be successful.

59. We emerge from the analysis therefore with a somewhat confusing and mixed picture. However, there seem to be some common threads. We offer these in the form of nine propositions, which we believe the bulk of what little evidence there is, generally supports.

(i) In the absence of scientific study of long-term changes in productive potential it is extremely difficult to prove or disprove the extent and seriousness of irreversible degradation;

(ii) The last two decades, during which most observations have been made, have in general been drier in Africa than previous decades this century. Natural vegetation and crop production are closely positively correlated with rainfall, and have been correspondingly reduced during the dry period although recovery of apparently irreversibly degraded areas following better rainfall can be astonishing, even to experienced observers. Future weather trends cannot be predicted with confidence, but wide fluctuations are likely. Dryland strategies must take account of the expected wet and dry years in future.

(iii) Advancing sand is not the major global dryland problem although it is serious in certain localized areas. Desert boundaries have in the past both advanced and retreated (often leaving fossilized dunes) and can be expected to continue to do so. (See, for example, Heathcote, 1983 who notes that "the advancing sand dune is in fact a very special and localized case and a popular misconception of desertification.")

(iv) Degradation radiating out from centers of excessive population pressure in many scattered arid, semi-arid and even sub-humid locations is a serious global problem. The solutions are elusive and vary widely from case to case. (Such occurrences were described by Major F.M. Oliphant, a colonial forest adviser, in his comments on Stebbing (1935) as "... the creation of small, internal saharas by burning, uncontrolled cutting and grazing, and shifting cultivation.")

(v) While the pattern of irreversible degradation can vary widely depending on cause and soil type, there seems to be a pattern of a long period of very slow decline, followed by an acceleration, often through the agency of a few isolated catastrophic events, followed by a slowing up at a low, relatively stable, plateau. (See, for example, Walter et al (1981) who note that "Degradation may result in a very stable but less productive state, such is caused by overgrazing of certain environments.")

(vi) In most dry cropping areas we do not yet have more than a very few profitable improved systems (groups of technological and management practices) that will permanently maintain fertility

under high population pressure without uneconomic levels of artificial nutrients, but we have some promising, although still not widely adopted, moisture conservation systems.

(vii) In most dry range areas we do not yet have significantly better management systems than those that exist which will maintain productivity while ensuring vegetation protection for the soil and the survival of the people dependent on those areas.

(viii) National policies may be extremely important, particularly, land tenure, prices and subsidies and legislation on natural resource use and authority for local taxation.

(ix) There seems often to be a crisis point natural resource/population threshold up to which there is a tendency to mine resources, but beyond which cooperation emerges albeit often too late to prevent at least some degree of degradation.

60. There is a need to monitor the extent of desertification and to probe the causes more deeply because there has been too much exaggeration and unfounded assertion. Dregne (1987) says: "Aside from the need for more reliable information than that provided by guesses and estimates in understanding where desertification is worsening or improving we need data because the credibility of statements on desertification is now in question. Claims that the Sahara is expanding at some horrendous rate are still made despite the absence of evidence to support them. It may have been permissible to say such things ten or 20 years ago when remote sensing was in its infancy and errors could easily be made in extrapolating limited observations. It is unacceptable today."

61. It is also important to understand the extent of desertification to decide when it crosses the boundary from being an ordinary farm or range management problem to being a policy problem. Spooner (1987) has asked an important question: "When does it become a policy problem? Though the question is heretical -- are we crying "wolf" indiscriminately?"

V. IDENTIFYING THE CAUSE

62. A superficial understanding of the physical extent of desertification is of limited value in developing strategies without also understanding the cause. Causes are far too often unhelpfully described as loss of trees, soil erosion, overgrazing, etc. These are not causes; they are symptoms. One has to probe deeper for the real causes that signal strategy responses. At a very general level Sandford (1976) has examined the four main views on the causes of desertification.

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(1) The structural arguments, laying the blame on social and economic structures.

(2) The natural events arguments, laying the blame on largely uncontrollable climatic events.

(3) The human fallibility argument, laying the blame on the short-sightedness of pastoralists, governments, donors and others.

(4) The population argument, laying the blame on human and animal population growth.

Our own hypothesis would be that about 70% of the problem can be attributed to natural events and population growth but that significant progress can still be made by working on the other 30%, particularly on social and economic structures and the lack of technologies, which lies in Sandford's human fallibility realm. Some progress will be possible on the 70% through climate research and population work. It is worth noting that pastoralists and agriculturalists themselves often favor the natural events argument. The natural events cause argument, at least with respect to the Sahel, remains a matter of considerable scientific debate. The bulk of the scientific opinion still appears to reflect the view that long periods of low rainfall such as have been experienced recently are to be expected. For example, research shows (Johnson pers. comm.) that Lake Turkana has been both 80 meters higher than its present level and 60 meters lower, but this is over a very long time period. It seems clear that planners should not rule out the possibility that we are entering a drier period which cannot yet be clearly discerned in the data. Complicating the issue is the "feedback" theory, not well established yet, that loss of vegetation, through various linkages, reduces rainfall.

63. The superficial identification of causes of desertification is paralleled by the frequently poor identification of the causes of failure of dryland projects. For example, reasons given for failure of the Arid Zone Afforestation Program in Nigeria (reviewed in Anderson, 1987) include insufficient protection from livestock, inappropriate choice of species, lack of soil fertility, late planting of trees, failure to water and poor transport. Of these only poor choice of species and transport appear to identify a true cause. Insufficient protection from livestock points to a less proximate cause, the question of why the incentives or materials for protection did not exist. Lack of fertility is more a fixed constraint rather than a cause since it is partly for this reason that trees are needed. Late planting of trees again points to a less proximate cause. Failure to water is likely also to be related to other causes; e.g., distance to water and/or wealth to be able to purchase water. These identified causes of failure are more often constraints that technologies have to adapt to rather than constraints that must be removed so the technologies can be feasible. Technologies that are not feasible and profitable and cannot readily be made so are not, by our definition, valid technologies.

64. In understanding the causes there is a need to focus much more on describing the biological and social historical sequences that have led to the present situation. More utilization of historians from local universities and the introduction of the historian as an essential discipline in donor institutions is overdue. As E.E. Evans Pritchard said in an address to the Aquinas Society at Oxford in 1946 "Anthropology is nothing if it is not history." But the incorporation of a historical perspective into our analysis of causes to provide a dynamic view of the evolution of farming or pastoral systems and of societies and vegetation over time demands also a balancing perspective on the future evolution to be anticipated. If we look back over the last 100-200 years to times when population pressure was much lower, we must also, to develop a balanced strategic perspective, look forward at least 50 years to the time when, at least in some countries, the growth of other sectors of the economy may result in reducing dependence on difficult dryland areas. It is still far too early in most African countries to anticipate reduced rural population pressure. However, it is not too early in some countries, to start to anticipate such changes in the setting of priorities in a highly resource-constrained situation and a number of countries in the Middle East and North Africa are well into this phase of evolution in their economies.

VI. APPROPRIATE STRATEGIES

65. This section documents the nine most important strategic elements that arise from the characterization of the problem of desertification outlined in this paper. Omitted here, because they are to some extent subjects in themselves, are strategies relying on irrigation and on formal or informal urban income generation. Both of these may be extremely important and may both play a role in a balanced strategy in any country. Indeed, in the higher income developing countries (e.g., Chile, Peru, Morocco) and in the developed countries (e.g., USA, Australia, Israel, USSR) these are the main strategic elements. Here we focus on strategies for rainfed rural development. A broad framework for thinking about national strategies is offered in Chart 2. It includes the people area, the research and technology area, the economics and policy area, the legislation area and the institutional area. Infrastructure is not explicitly covered because appropriate infrastructural investments are assumed to be an outcome of the development of appropriate strategies.

66. First, the lack of knowledge and the misperceptions about the extent and causes of the problem suggest the need for attention to the development of modest scale permanent national systems of land monitoring. Obviously these must be based as much as possible on low cost remote sensing and perhaps low cost Systematic Reconnaissance Flights (UNEP, 1986), supported by sufficient ground truthing to validate remote sensing and, particularly, to check areas which remote sensing has indicated have failed to recover following the return of better rainfall. These are likely locations of emerging, difficult to reverse, degradation. The

difficulty here is: what level of monitoring is optimal? Is the absolute minimum cost effective method likely to be economic and permanently affordable when we know that measurable changes can be demonstrated only over several decades (Dregne and Tucker, 1988)? If no level of effective permanent monitoring is economic and affordable by a poor country should international grant support pay for it? On what grounds? Are there sufficient global external effects to justify this?

67. Examples of monitoring systems to look at are the ILCA-developed rangeland monitoring system combined with the use of AVHRR data, Kenya-KREMU and India-CAZRI, UNEP has experience of many others. The need is not simply for better quantification of the aggregate seriousness of the problem, it is for better mapping to show where it is (Dregné pers. comm.). Given the difficulty and costs of quantification, qualitative techniques such as ordinary ground photography (snapshots) (e.g., Shantz and Turner, 1958) and perhaps systematic video tapes filmed from the ground or the air should not be discounted as useful evidence.

68. Second, the lack of knowledge about technologies suggests the need for more attention to technology research in dry areas. This is easily offered advice, but a government is entitled to ask what is the priority relative to other priorities, for example, research in more humid areas and even outside the sector, in education or health? This question has to be answered for each country. However, in answering it, due allowance must be made for the opportunity cost of ignoring the dryland areas or making mistakes with them (Swift pers. comm.). The cost of failure in terms of famine relief, social disruption and even civil strife may be substantial. The costs may spill outside the dryland areas themselves, for example through unmanaged desperate and disruptive migration.

69. Substantial yield increases have been achieved for some humid area crops. It is doubtful whether this can be replicated widely in dry areas. However, where technology can lift crop survival over a threshold or reduce risks there may also be substantial returns to be found. Yields well over two times the control technology were obtained in Baringo in Kenya. Another consideration is equity. The population density relative to carrying capacity in dry areas is often higher than in more humid areas (e.g., in West Africa). This alone may justify increased research investment, although in these situations the possibilities of spontaneous migration to the more humid areas may be an alternative for a small part of the population. In addition to research, active demonstration of the limited number of available technologies may be more important in dry areas. In lower density and less intensive areas where families are more spread out, actively transporting selected farmers or pastoralists to see successes elsewhere, perhaps where population pressure is somewhat greater, or where rainfall is lower and thus closer to the new conditions, may be very productive. This has proved useful in Burkina Faso and Mali (McGahuey pers. comm. and Toulmin pers. comm.)

70. Third, the lack of knowledge on the extent and causes of the problem and the variability and complexity of the different resource situations in different zones, suggests the need for much more attention in research in dry cropping and pastoral areas to farm and pastoral systems studies and to the economics and risk of technologies. The need is for more location-specific design of technologies and for more attention in adaptive research to the analysis of profitability and risk. The literature on technologies for improved land management and crop and livestock production in dry areas, and the evaluations of attempts to introduce those technologies, is remarkable for the few calculations of financial returns to labor or to cash investment. It is also remarkable for the almost complete absence of calculations of worst year outcomes and their probability, and the likely difference between men's and women's income from the particular technologies.

71. One difficulty is that appropriate technologies vary from location to location. In land surplus areas (Carr pers. comm.) labor is the constraint, and the intensification strategies often considered by researchers and extension staff to be good husbandry (early planting, good weeding, fertilizer, etc.) are frequently poor management because, while they may increase yield in parts of the system, they reduce overall income and income reliability. In intermediate areas land is becoming the main constraint and farmers may be newly faced with the need to work harder simply to maintain or even steady the rate of fall of their income, a difficult psychological transition to make, demanding a particular package of technologies because declining real incomes is likely to be accompanied by increased discounting in the perception of the farmer of future costs and benefits, at least initially. In land scarce areas, maximizing the efficiency of nutrient recycling and optimizing the distribution of what little water there is becomes critical. In spite of considerable research, it is still not clear in many soils whether, with agroforestry and continuous cultivation in high population density areas (i.e., in the absence of shifting cultivation), acceptable profitable and sustainable technologies can be found that do not require unprofitable levels of fertilizer application or, alternatively, unsustainable subsidies. Concentrating water does not concentrate nutrients.

72. The problem in dryland soils is related to structure as much as to nutrients. Manure, and more particularly manure making and protection methods, are certainly important, but how much vegetation is there in these areas to make manure? Manure does not add nutrients to a farm unless it brings something in from outside. Thus there are limits to the supply as grazed areas shrink. There is an increasing need to focus on the efficiency of crop/livestock interaction, but operationally it is often difficult to define precisely what we think should be improved.

73. Finding improved but low risk crop cultivars for dryland areas is also difficult. Among some 7,000 sorghum introductions screened by ICRISAT in Burkina Faso, nine cultivars went on to on-farm tests and only two were

found to be possibly superior under farming conditions. No superior cultivars of millet were found. Furthermore, in a highly variable environment testing for superiority on a number of criteria takes a long time, although rainfall variability between sites can, to some extent, substitute for rainfall variability between years.

74. Fourth, the complexity, and local variability of the problem of land degradation suggests that there are no global or regional technological solutions and that large programs such as tree belts across Africa are not a solution although they may eventually be the result of a solution. A common misperception favoring large regional programs is the idea that if, for example, tree planting for shelterbelts increases in Burkina Faso but not in neighboring Mali, somehow the work in Burkina will be negated and the desert will creep round the ends of the barrier. But as we have noted above, the advancing desert front characterization of the problem is not the major global phenomenon and such spatial interdependences seem to be rather uncommon. (Although if a climatic link between reduced vegetation and rainfall is proven the issue will take on more complex dimensions.)

75. Fifth, and arising partly from the points just mentioned, since there are no obvious globally applicable solutions and rather few technologies, and since therefore much will depend on small pilot projects and local community experimentation and development which takes time and must rely largely on within country expertise, large quantities of donor funds thrown hastily at the problem will not solve it. Indeed, they will probably handicap later more thoughtful initiatives. In this respect it is tempting to see the multiplication of the small pilot scale grass-roots development program as the lynch pin of a strategy. While such programs sometimes have achieved very promising results, and certainly warrant increased support at this early stage, the means by which these can be replicated more widely often are not available. For the longer run, governments may have to take a more replicable approach by gradually building up nation-wide research and extension and community development capacity to support village-level participatory development on a selective, but expanding scale. (See p. 16 of IFAD's excellent 1987 paper on Soil and Water Conservation.)

76. Land tenure becomes a central issue in such participatory development. Two influences are discernible. The first is an increasing understanding in donor and borrower institutions that social structures influence land use and can be supported, and sometimes firmly nudged, towards improved land management (where there is knowledge of what this involves). The second is an invasion of outsiders which pushes the situation more towards a "tragedy of the commons" and reduces the likelihood of cooperation. Group land rights become very important in such a situation.

77. Sixth, the complexity of the problem and the local variability and the need for experimentation--much of which it is better to think of as "search" (for technical and social solutions) rather than "research" (which carries the connotation of formal academic studies)--suggests the need for predominantly village-level initiatives developed from small-scale local experimentation rather than large regional programs. However, such village-level initiatives must be supported by appropriate policies and investments in the five areas summarized in Chart 2: the people area, the research and technology area, the economics area, the institutional area and the legislation area.

78. What little global or regional coordination is possible above the local and country levels should come largely in the form of transfer of experience and of research data between different countries within the same agro-climatic zone (e.g., across the Sahel Sudanian zone) or within the same social situation (e.g., between similar types of pastoral society). This would imply that the main coordination priority should be with regional institutions (e.g., CILSS) leaving more global institutions to orchestrate only the broader coordination networks. The availability of transferable approaches between continents may in one sense be quite limited. For example, experience suggests that even between neighboring villages appropriate interventions may be quite different. Under these circumstances, the only possible commonality would be through lessons on the process of adapting to these differences. One such process innovation may be the alteration of the type of extension system that simply promulgates messages, to one which supports farmers in experimenting more themselves with a wider menu of options provided by the research institutions (see Chambers, 1987). However, in another sense, there may be useful lessons to be passed between countries from those who have been through certain rural land/labor ratio phases to those who are approaching those phases.

79. Seventh, the failure and the high cost of the "decide-how-many-trees-you-want-where-and-plant-them" types of project directs attention to addressing the overall policy environment. Both the enabling types of incentive policies, such as land tenure and the variable types of incentive policies; e.g., prices, taxes, etc. may be important. The need is to get spontaneous responses from millions of small farmers and pastoralists rather than for government to tax them to get the money and then to do it for them.

80. Eighth, the difficulty of finding solutions to the soil fertility problem and the substantial variability of population density forces attention towards spatial strategies for development. This might be either towards considering the benefits of assisting spontaneous migration, or towards deliberately chosen investment priority areas, knowing that migration might in due course arise from these choices. Historically, the economies of the desert and the savannah have been closely interwoven (Baier, 1976) and, indeed, it can be argued that the closing off of much of

the movement that used to occur has been a major contributor to the problems of the present. The possibility of facilitating spontaneous migration, but also the practical and political problems associated with it, need very careful investigation in many countries, particularly where cross national boundary migration is occurring. Migration to higher rainfall areas may not necessarily be environmentally sound; indeed it may result in a national increase in land degradation. Heavier rainfall may increase the potential for soil erosion and soil acidification associated with continuous cultivation (McGahuey pers. comm.). Furthermore, if forced resettlement becomes the outcome of a focus on spontaneous migration experience suggests it is likely to be disastrous. Studies of this migration issue, particularly land tenure arrangements in receiving locations, need to be undertaken.

81. Ninth, the difficulty we have identified of finding new technologies which are acceptable to farmers has been largely related to the poor farmers'need for immediate, substantial and reliable returns to trigger adoption (probably represented in farm management analysis by as much as a 50% perceived discount rate on the average outcome). In the past this short-time preference and risk avoidance focus has probably overridden any lack of security of tenure as a constraint on a longer-term view. As population density increases, soil conditions deteriorate, trees disappear and the alternative of moving to new land is removed, farmers, and perhaps women sooner than men, do seem to start to focus again somewhat more on the longer term (e.g., the Machakos-Kenya soil conservation experience and India and Malawi tree planting). At this point, which has been reached now in many locations, security of land tenure may become more critical. However, in many cases land tenure is quite secure and in many other cases land tenure evolution seems to be responding appropriately to the pressures without interference from outside. Therefore great care is needed not to move into this area in a heavy handed way. The first step is to understand what exists.

82. The complexity and the difficult strategy choices implicit in the nine points discussed above underline the need to explicitly recognize the environmental and development trade offs rather than pretend they do not exist. In the issue of land management in dry areas, the frequently held view that there is no conflict between development and the environment is either untrue or true but not operationally useful, depending on ones definition of development and environment. There is always a choice between alternative actions and particularly between actions now and actions later, and there is always the strong possibility of making the wrong choice, either for development or the environment or for both. The common perception that one cannot afford to ignore the problem of desertification is not a useful characterization of the problem. Resource constraints dictate that any strategy will ignore the problem to a degree. The other side of the coin to the appropriate level of action is the appropriate level of inaction. The strategic question is: What are the social and economic benefits both now, and in the future, from investing in

dryland management relative to investing elsewhere? They may be very high. But this paper has argued that to be able to deal better with the problems of dryland management we need more knowledge on the extent, causes and appropriate institutional and technological responses to this complex problem.

VII. IMPLICATIONS FOR THE WORLD BANK'S STRATEGY AND OPERATIONS

83. What are the strategic and operational implications for World Bank work of the diagnosis offered? Clearly the answer is not to sit back and do nothing until more is known. The downside risk of complacency is too high given the possible irreversibilities. The two main questions are: What level of resources should one throw at the dryland problem? and, How should one design those interventions knowing that the efficiency costs of excessive or misdirected investments are also high?

84. We discuss here, first, four broad strategic objectives for Bank lending in dryland management and, second, twelve points of operational importance for lending. We suggest that the four main strategic objectives for the Bank in lending to dryland areas of the world might be the following:

i) To increase incomes and improve food security through efficient resource use to an extent compatible with sustaining the productive capacity of dryland areas;

ii) To the extent that population pressures and lack of technologies render the sustaining of minimal incomes without resource degradation temporarily unrealistic, then at least to ensure that the burden of income adjustment is fairly shared between present and future generations and between those living in lower and higher potential areas. Furthermore, in any such unavoidable "land mining" operations, to be fully aware of the likely outcomes.

iii) To facilitate necessary adjustments (e.g., spontaneous out-migration) in a manner as compatible as possible with the wishes of the people of the departure and receiving areas affected.

iv) To the extent possible, without excessive human hardship for either present or future generations, to maintain the bio-diversity of the dryland areas as a future resource.

85. Clearly within these four broad strategic objectives there are enormously difficult definitional problems, conflicts and trade-offs which, in the course of project design and implementation, must be faced by Bank operational staff, borrowing governments and farm and pastoral families.

86. Some operational implications for the Bank of the diagnosis in this paper appear to be the following:

i) The Bank should probably somewhat increase its lending in dryland areas over the pre-1987 level because of the possibly very high costs of inaction. That change seems to have been reflected already in the lending program. There are about 30 projects coming forward over the next two to three years which will impact to a greater or lesser extent on dryland areas. It is very difficult to compare past actual lending with proposed future lending for an activity that is not clearly defined and where projects come into, and are dropped from, the lending program over time. However, we believe that this future lending program represents a considerable increase. The amount of funds that would impact directly on dryland areas appears to be of the order of $200 million per year. In Africa these proposed dryland projects represent about 30% of the total number of proposed projects in agriculture and about 20% of the proposed agriculture lending. Such percentages seem appropriate to the scale of the problem and the potential benefits, but there is no way yet of demonstrating analytically that lending for drylands relative to other lending should not be higher or lower than this.

ii) The Bank should be wary of large national anti-desertification initiatives unless (which at present is unlikely) it is clear that strategies and technologies are well understood and policies have been improved. However, substantial "umbrella" projects aimed at policy change and national institution building and training may still be justified to support smaller field-level initiatives.

iii) The Bank should ensure increased staffing for Country Departments dealing with dryland countries to allow the appraisal of more, but smaller, projects and to allow more intensive supervision.

iv) Bank staff should question for accuracy all data on desertification and should question the strategy of all projects designed simply around an aim of halting expanding desertification. Such projects may need more thoughtful diagnosis of the problem.

v) In all dryland projects the Bank should satisfy itself that national cost/effective monitoring of land degradation at least has been adequately reviewed, even if the conclusion of such a review is that only very low levels of monitoring are economically justified.

vi) Project preparation studies in dryland areas should incorporate a historical perspective and should review historical evidence on land degradation to establish a better perspective on the causes of the problem. Much of this can be done by local universities but the Bank should consider recruiting a historian on a trial basis.

vii) The Bank should put a substantial proportion of dryland project funding into applied research, farm and pastoral systems studies and the search for (as opposed to research on) better systems for participation and cooperative management of resources.

viii) Projects in high population density dryland areas usually should include research on soil fertility issues or have parallel research projects closely linked to them. (The Bank needs more in-house technical agricultural expertise for work on such issues.)

ix) The Task Force on Desertification should, in conjunction with regional environmental units, initiate the following coordinated series of studies over the next two to three years:

- o a comparative review of the lessons of experience of successful and unsuccessful projects across the main dryland areas of the world with a particular focus on: the influence of the incentives environment, the profitability of improved technologies and systems, and the preconditions for effective collective action on resource management.
- o a study to develop land tenure policy recommendations for some case study countries aimed at improving incentives for better land management.
- o a review of the state of the art and the cost effectiveness of the various alternatives in land degradation measurement, to be developed into a practical guideline and training material for Bank operational staff.
- o a study to develop guidelines on Bank support for spontaneous migration. (The proposed UNDP-funded, World Bank-managed Onchocerciasis-Freed Areas Migration Study is expected to contribute to understanding this issue).
- o a study of the economic returns to investment in dry areas compared to higher rainfall areas to investigate the commonly-held hypothesis that returns in dry areas are lower; this will call for putting a price on land degradation in the "without project" situation.

x) In cooperation with borrowers, the Bank should gradually try to develop links between the dryland projects which it funds in order to evolve, over time, a flexible global applied research network. This would involve testing similar processes of participation, technology adaptation and policy adjustment across projects. The new IIED dryland networking proposal might be used to forge similar links with other non-Bank funded projects.

xi) The Bank should review the absolute and relative (to higher rainfall areas) amounts of resources going into international and national research programs for dryland areas to ascertain whether resources for this purpose are adequate.

xii) The optimal extent and level of coordination between the many agencies working on dryland management is a particularly difficult issue to resolve. It is not simply a matter of more coordination. Coordination has a cost as well as a benefit. Quite a lot has been happening. There is in this field of dryland management, as in many others, rather little that is new. If one probes far enough someone, somewhere, has either done it or thought it. Notwithstanding the often unduly pessimistic assessments in international fora of the extent of government and donor responses to desertification there have been a considerable number of initiatives by governments, NGOs, donors and by international agencies, such as UNEP, FAO, UNESCO, UNDP, UNSO, WHO, WMO, etc. The still limited impact means that evaluation and networking are very important. It seems unlikely that, at the global level a completely coordinated international and operationally useful strategy to tackle such a diverse issue as desertification is feasible. Nevertheless, a single international forum of the DESCON or IAWGD type can help develop common understandings about the issue, while mot of the strategy and program coordination takes place at more disaggregated levels, either regional, such as through CILSS, IGADD, etc., or through country donor/NGO/borrower meetings. At the higher international level coordination should be predominantly data and ideas exchange. Dryland management is such a diverse topic, overlying as it does forestry, soil conservation, crop and livestock husbandry, sociology, etc., that it is difficult to conceive of a Desertification Action Plan similar to the Tropical Forestry Action Plan. The span of focus is so much wider.

87. The characterization of desertification outlined in this paper delineates a problem of uncertain dimensions and difficult multi-disciplinary solutions. This presents a dilemma in developing a response. On the one hand one might argue that if dry areas are so difficult then one

should neglect them and concentrate on higher potential areas. On the other hand one might argue that if they are so difficult then one should put even more resources into developing them. The dilemma can only be resolved by a better understanding, at the country level first, of the economic trade-offs, second, of the needs of the poor and third of the "externality" connection, that what is neglected in the dry areas affects, through various "knock-on" impacts (externalities), what happens within the whole economy. Many factors such as soil erosion, migration of people or livestock, flowing water, investment opportunity costs, political instability, income changes, population growth, have impacts <u>outside</u> their zone of origin. Therefore the dry areas <u>are</u> usually important, even if alone they may seem less important. The strategic question of what proportion of resources should be applied to these areas and in what manner and with what benefits becomes a country specific question which calls for explicit attention. Dry areas are very different from high rainfall areas with respect to solutions. For the Bank and its borrowers improved dryland management must be addressed, over the next five years, as one of the major and most intractable global development issues.

88. While this paper has presented a somewhat pessimistic view on the availability of solutions to dryland problems, this does not mean that action by the Bank and others must wait. It means that actions must be thoughtful, modest and must be evaluated, and expectations must be realistic. Ten-year failures may turn into twenty-year successes. Five-year successes may collapse into twenty-year failures. Furthermore, means should not necessarily precede ends in the falsely logical sequence of the traditional project cycle. Means and ends require mutual adjustment. Johnston and Clark (1982) have the best illustration of this in their story of the Eskimo carving a piece of bone, initially not being sure what he is making, exploring the bone for its possibilities and carving a bit more, until finally: "Hello seal, I wondered if it might be you." Means and ends should develop as one, mutually adjusting to each other. It is a style particularly suited to the enormous uncertainties of dryland situations, but in some respects the antithesis of large internationally coordinated anti-desertification programs. The challenge for large agencies like the Bank is to aid the small, the participatory, and the experimental on a large enough scale to make national rather than simply local progress, but without massive public expenditures. Policy surely has to be a key.

Table 1: UNEP Desertification Estimates

	Rangeland		Cropland (rainfed)	
	Total Area (M.ha)	(%) Desertified	Total Area (M.ha)	(%) Desertified
Sudano-Sahelian Africa	380	90%	90	80%
Southern Africa	250	80%	52	80%
Mediterranean Africa	80	85%	20	75%
Western Asia	116	85%	18	85%
Southern Asia	150	85%	150	70%
China and Mongolia	300	70%	5	60%
South America and Mexico	250	72%	31	77%

Source: Mabbutt, J.A., "A New Global Assessment of the Status and Trends of Desertification," Environmental Conservation, Vol. 11, No. 2, 1984.

Table 2: Percentage of Land Area Affected by Region

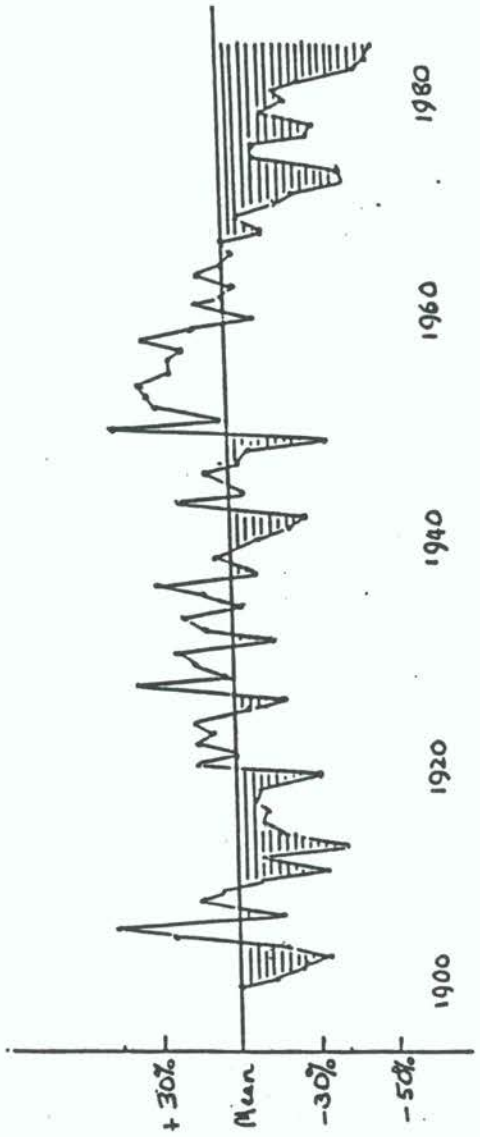
	Africa	North America	South America	Europe/ Asia	S. Asia/ Australia
Salinization	1	<1	1	3	1
Cementation 1/	7	1	1	2	21 2/
Wind ablation/ accumulation	8	0	2	3	0
Water erosion	8	6	7	16	5
Aridic conditions	1	4	0	3	1

Source: Explanatory Note to Map of Desertification Hazards, May 1984.

1/ The total area of Gypsic, Calcic (meaning calcidic, i.e., carbonate), Silica and Ferric cementations. In this row, figures of <1 for the individual types of cementation were taken as 0 if one was present, and 1 if more than one was present.

2/ High levels of silica cementation.

Chart 1



Rainfall in the Sahel: departures from the long-term average; statistically random rainfall sequences may show large cumulative departures.

[Sources: National Research Council, Washington (1984); Folland, Parker & Palmer (1985)]

Chart 2: DRYLAND MANAGEMENT (DESERTIFICATION) STRATEGY CHART

Defining the Desertification Problem	Categories of Solution	Examples of Possible Solutions (Studies and Actions)		Operational Synthesis
1. Globally and locally, what is the evidence for the extent and type of the problem and what are the real causes? (Loss of trees, loss of soil, changed vegetation are not causes) 2. What do carrying capacity calculations, nutrient or energy flow models and population projections suggest for the future? 3. What has been the role of climate? 4. How irreversible is the problem? What sort of externalities are there spatially and intergenerationally? 5. Is it something more than a normal farm or pastoral development problem? 6. What more needs to be known to find a solution? 7. What measurements of the problem do we need to set in place?	PEOPLE	1. People/community involvement in natural resource management	* Develop a participatory approach with delegation of authority at the local level (e.g., Burkina, Senegal) * Examine laws relating to local organizations to ensure their activities are not hindered (see Desertification paper) * Review extension modes. Relevance of T&V versus other approaches * Review implications for agricultural education of strategies to improve resource management	1. Understanding the politics and getting commitment 2. Planning finance and staff 3. Developing participation 4. NGO liaison/involvement 5. Farm and pastoral systems studies 6. Pilot programs 7. Management including financial 8. Monitoring and Evaluation and redirection 9. Training 10. In-country seminars 11. Deciding on the optimal sequence towards integration 12. How fast to go? Reconciling enthusiastic targets with realistic expectation 13. Donor coordination 14. Relating to national programs and policies 15. Using resources efficiently for replicability 16. Developing long-term commitment 17. Choosing priorities (understanding that a resource committed to the program is a resource removed from somewhere else. What has it been taken from?
		2. Reducing population pressure	* Family planning * Carrying capacity studies for setting priorities * Support for spontaneous resettlement (see Desertification paper) * Urban employment or rural development centers program	
	RESEARCH & TECHNOLOGY	1. Generation of new technology and adaptation of existing technology	* Rangeland: (Fodder species, grazing management, satellite imagery, reseeding, wildlife systems, livestock integration, agro-sylvo-pastoral systems, calf management, veterinary, rumen microflora amendment, etc.) * Rainfed cropping: (Dry area cultivars, e.g., millet, sorghum, cloning of selected tree specimens, inoculation with symbiotic micro-organisms, water harvesting/soil conservation, small-scale irrigation, composting/green manure, shelterbelts, conservation tillage systems, agro-forestry/alley cropping * Household (Improved stoves, fuelwood production, charcoal technology: technology, substitution fuels, water pumps, cottage industry, processing technology, etc.)	
		2. Strengthening institutional support for research	* Institutional: (Strengthening institutional support for research, reviewing budgetary allocations, reviewing program balance between wet and dry areas, etc.)	
	ECONOMICS & POLICY	Improving knowledge of incentive and budgetary policy impact on environment	* Impact of prices on rainfed cropping, land management, and extension of cultivation into marginal areas (e.g., is there a case for fertilizer subsidy?) * Impact of cattle prices on rangeland stocking rates * Impact of fuelwood prices on incentives to grow/use fuelwood * Impact of fuel subsidies in reducing pressure on wood harvesting * Review budgetary implications of soil conservation subsidies and legislative control, etc.	
	LEGISLATION	1. People	* Change legislation which does not facilitate local organizations working for a common cause	
		2. Land tenure/ ownership	* Incentive of different types of land rights. Increased security of tenure in return for management responsibilities (e.g., Niger?) * Role of borehole legislation and control in rangeland (e.g., Botswana problem), etc. * Restriction of access to common property woodland resources complemented by incentives for improved management (e.g., Malawi?)	
	INSTITUTIONAL	Linking government with people	* Develop local organizations, train community development staff * Place responsibility for integrated planning and policy development on one central institution (e.g., President's Office) * May need to integrate planning but implement through a number of existing sectoral agencies. Clarify responsibilities. Monitor.	

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