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An Assessment of Desertification and Land Degradation in Arid and Semi-Arid Areas

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INTRODUCTION: THE POINT AT ISSUE

Beneath every debate about desertification there lies one over-riding anxiety: can the use of dry lands be sustained?

Desertification in its least ambiguous form, is the notion that the extent of deserts - dry areas with few plants - is increasing, usually into the semi-arid lands. It is to this commonsense and original meaning that we wish to restrict the term (Aubreville 1949). We need to make this clear because, in some circles, desertification now has a much wider and less precise meaning, namely: "the diminution or destruction of the biological potential of the land, that can lead ultimately to desert-like conditions". The reference is usually to dry lands, but sometimes even to humid ones. Defined like this, the term is full of ambiguities, not the least of which is the confusion between commonsense understanding of desertification and land degradation.

The idea of land degradation cannot be separated from that of sustainability. A form of land use is sustainable if it can continue indefinitely, and sustainability therefore depends on properties both of the resource and the way it is managed. The quality in a resource that renders its use sustainable is its resilience, but resilience can also only be defined for a particular form of use (a field that would be resilient if organically farmed might not be resilient if used for camel racing). Because of its dual nature (land use and environment), resilience is therefore very variable from place to place and even from time to time. A good test of the resilience of a resource is its ability to recover from a shock, be it climatic or a change in land use. The bigger the shock absorbed, the greater the resilience. A recurrent shock in dry lands is drought, and it is usually drought that brings land degradation or desertification to notice. Land degradation, very simply, is loss of resilience. A measure of degradation is the cost of rehabilitation.

Land degradation, which encompasses desertification, is both a better description of the great majority of the problems we address here, and has yet to suffer from the erosion of meaning that has attacked the term desertification. The rendering of an area desert-like is a minor and localised threat to sustainable use. Land degradation, usually well short of desertification, is undoubtedly more widespread and, in aggregate, much the more serious menace to sustainability.

THE IMPORTANCE OF CORRECT DIAGNOSIS

The inclusion under "desertification" of almost all forms of land degradation, as in these definitions, is now widespread. The term desertification is even used to include resource degradation in humid areas (Glantz and Orlovsky 1983). This broadening of the definition robs it of almost all diagnostic value.

The argument about such definitions is primarily about diagnosis. Effective measures against an environmental (or any other) problem must rest on as precise a diagnosis as possible. If the problem is thought to be a drought, lasting no more than two or three years, food aid may be adequate. If it is seen as climatic change, permanent withdrawal is called for. If there has been near-complete devegetation, in the absence of a climatic change, the treatment is re-seeding or re-planting. If the diagnosis is that the desert is actively expanding at its margins, then some kind of holding-line might be the answer. If the problem is falling productivity because of over-grazing, over cultivation, or over-watering, then the agricultural sector will need help to develop more appropriate land-use practices.

A common type of confusion that follows where "desertification" is diagnosed, but where land degradation is the real problem, is locational. It has been seemingly impossible totally to dispel the notion that the principal problem in arid areas is the expansion of existing deserts (Dregne and Tucker 1988). Governments and agencies have been party to the repeated use of terms like "spreading deserts" and dwell upon statistics of desert expansion. The habit is catching:

> On the 14th of March, 1986, Vice-President Bush was being urged to give aid to the Sudan because "desertification was advancing at 9 km per annum."
>
> On the 11th of September, 1986, in a debate in the European Parliament on the subject of aid to Africa, Winifred Ewing (Scottish Nationalist) declared that aid must go to the Sahel, because the desert was advancing at 8 km a year. (Agence France Presse).

These misled statements are made despite repeated acknowledgement by the authorities that the most serious problems in semi-arid areas do not occur at the desert margins (UNCOD Plan of Action 1977). Few people in any case live there, and the most destructive forms of land use, such as cultivation and intensive grazing, do not take place there.

One practical consequence of this emphasis on the desert edge is the notion that it is there that the priority for action lies. One of the most popular of the solutions for desertification is green belts, shelter belts, or <u>ceintures vertes.</u>

Another consequence of misapprehensions about desertification, fueled by the belief that desert-spreading is the primary problem, is the planting of sand dunes. In many countries, the first thought that comes to the minds of those who are charged with halting desertification is to plant dunes. This has happened in Algeria, Iran, Sudan and Somalia. Planting, though costly, is a technically and logistically simple operation. And yet, as we will show, active sand dunes seldom threaten valuable land, and in some places the area covered by active dunes has been shown to be stable, even under considerable stress. The cost/benefit ratio of planting is low or negative. But planting is visible and gives the impression that something is being done.

It allows organisations to avoid tackling the much harder social and economic problems of insidious land degradation.

THE LIMITED DIAGNOSTIC VALUE OF MOST EXISTING CRITERIA OF DESERTIFICATION

Most reports about desertification base their arguments on a litany of statistics, themselves derived from conflicting definitions. In a highly variable environment, how could one measure the advance of the desert edge, when moreover that edge itself is ill-defined (to say nothing about the poverty of the data)?

An example of a misleading statistic is the claim by UNDCPAC (1987) that 35 percent of Earth's land surface is threatened with desertification. Yet this is the area that is arid and at least half of that area is very arid: by UNDCPAC's own acknowledgement, this zone is not in danger - about half of it is too arid for any form of agriculture.

The conclusions of another widely quoted report of desertification have been strongly contested. Lamprey (1975) compared the position of the edge of the desert in western Sudan at two different times. The first was the edge plotted on a vegetation map by Harrison and Jackson in 1958. The second was the result of an aerial survey Lamprey himself conducted in 1975. He found that there had been a vast increase in the size of the desert: the desert edge had moved 90 to 100 km in 17 years. Apart from finding no evidence on satellite imagery to substantiate Lamprey's findings, Helldén (1984) pointed to a major flaw in this argument: Harrison and Jackson estimated the position of their vegetational boundary from a climatic map, itself based on an extremely sparse network of weather stations. Lamprey's criteria for desertification failed to distinguish between the effects of the drought at the time of his survey, and the effects of desertification. (Dregne and Tucker 1988). In their studies of parts of the same area, Olsson (1985) and Ahlcrona (1988) found plenty of evidence that the drought had affected yields and vegetation cover, but that there had been little longer-term damage to resources.

Another approach has been the measurement of desertification from satellite imagery (MacLeod et al. 1977; Walker and Robinove 1981; Tucker and Justice 1986). The results have not been *conclusive*. Tucker and Justice did indeed record major year-on-year variations in the amount of green biomass, but concluded these were related to rainfall rather than degradation. Moreover, their method, as in all satellite studies, can only measure production, not the more important productivity. To be a measure of land degradation, the method would also have to assume that plant cover values were a measure of sustainability, and this is another vast over-simplification.

There are a number of problems in establishing classes and rates of land degradation.

1. How do you set a standard against which to judge the present condition? For example, if the land was denuded of vegetation or severely gullied, was this because of a drought, overgrazing, or had it always been so?

2. How do you assess recoverability or resilience? Resilience is hard to determine and depends, not only on physical characteristics of the soil, but the land-use system.

3. The climate of arid and semi-arid areas, and in consequence the condition of the natural and planted vegetation, fluctuate wildly from year to year and decade to decade. It would be difficult, if not impossible, to determine whether the condition of the Sahel at any time between 1968 and 1984 was a consequence of long-term degradation or of drought. The same problem was encountered by the United States Soil Conservation Service, when it plotted damage to farmland in the drought and recession years of 1930s. Many areas seen then as irreparably damaged are producing record crops today (Held and Clawson 1965).

4. The data needed to classify land is available for very few areas, and for very few years. Data may be reasonably accurate in parts of Australia, the United States, and the USSR (though they are not beyond dispute even in these countries), but in most of Africa little is known about range condition or the extent of soil erosion, let alone crop yield (see Ahlcrona 1988).

5. What data are available have little relevance to the sustainability of local land use systems. Zones of apparent damage, defined at the scale of a continent or of a country, have little meaning to life on the ground. The scale at which desertification has usually been viewed has been determined more by the availability of data and manpower, than by its appropriateness to the inhabitants of semi-arid areas. Working at a scale at which the boundaries of damage could be accurately plotted, and from which realistic statistics might be derived, would raise insuperable problems, even for most provincial governments.

Most of the statistics that are now quoted in the discussion of desertification come from the UNDCPAC/Dregne approach (e.g. Grainger 1982), for example "each year 21 million hectares of once productive soil are reduced by desertification to a level of zero or negative productivity, and six million hectares become total wasteland beyond economic recoverability." (UNDCPAC 1987). And Dregne (1983) maintains that: "80 percent of agricultural land in arid regions of the world has experienced moderate or worse desertification." Because we believe that the approach on which these statistics were based was seriously flawed, we believe that the statistics themselves have little diagnostic value.

The problems of assessing degradation are not peculiar to Africa. Woods (1984) describes some of the difficulties with an exercise carried out in Australia to assess land-degradation. There, questionnaires were circulated, and resident experts asked to assess land according to how much work needed to be done to rehabilitate it. This seems to be a much sounder approach than

that outlined above, but, the survey reported by Woods (1984) also experienced problems with its criteria.

Something must be said about the simpler, and of course easier approach in which the movement of the desert boundary is measured. This was the method first used by UNEP in the approach to the UN Desertification Conference of 1977, and it is the approach used in satellite studies of the desert edge (e.g. Tucker and Justice 1986). Apart from the question of taking biomass as a proxy for productivity, already noted, there is the problem of establishing secular change in an environment as variable as the semi-arid. Dregne and Tucker (1988) note that:

> "A permanent vegetational shift of 5 to 6 km per year (could only be established with) perhaps 30 to 40 years of observation by meteorological satellites and ground studies...."

Despite our scepticism about the methods of assessing desertification and land degradation, we wish to stress that to claim that existing statistics are spurious is emphatically not to deny that problems exist, nor is it to wash ones hands of them. There are other ways to evaluate the problem, and we return to these later.

THE DISTINCTION BETWEEN ACUTE AND CHRONIC DEGRADATION

There is no argument that the loss of vegetation to the low levels of cover found in deserts is unfortunate. If nothing else, some vegetation, no matter what its character, is better than none for holding the soil against erosion. Such acute and extreme devegetation is unambiguously bad, and if it persists and covers large areas, the change would be universally be called "desertification."

Nevertheless, acute devegetation has been shown repeatedly to affect only small parts of semi-arid landscapes (Aubreville 1949: Helldén 1978: 1984), and has seldom been shown to persist.

The near-total removal of vegetation is neither the only, nor the most serious way in which resources can be degraded in semi-arid areas. A more serious problem is a chronic decrease in productivity, which afflicts a vastly greater area. We prefer the term land degradation for these processes.

Pastures. Pasture degradation and the creation of more desert-like conditions are not necessarily the same. Apparent desertification can happen where there is no pasture degradation, and conversely pasture degradation can occur where desertification is apparently in reverse (Sandford 1983). Five examples show this.

In central Sudan, Ahlcrona (1988) found evidence that pastures were being invaded by unpalatable species such as Calatropis procera, and yet at the same time that there had been no great

change on satellite imagery either of an albedo index (reflectance from the surface, indicating vegetation cover), or of a vegetational index (NDVI). In other words, there had been degradation but no change to more desert-like (less vegetated) conditions. She noted that the concept of desertification had been reduced by some workers to absurdity, when they had termed the change in vegetation quality (which often involved an increase in green biomass) as "green desertification".

In Mali, the sahelian pastures of the Fulbe pastoralists are of far better quality than those immediately to the south in the savanna (Penning de Vries and Djiteye 1982), so that a change that involved the invasion of the savanna by a vegetation type typical of the sahel would, to the Fulbe, be a change for the better. And yet this would be interpreted by those who used merely vegetation cover as a measure of desertification, as a change for the worse.

The Sinai/Negev border in southern Palestine exhibits what has been interpreted as a clear sign of desertification: it divides a well vegetated Negev in Israel from a sparsely vegetated northern Sinai in Egypt (Otterman 1974). Yet there are good scientific arguments for the case that pastures are more productive when they are grazed low - in other words when they appear more desert-like (Warren 1984a; Warren and Harrison 1986): up to a point, plants produce more new and fresh growth if they are encouraged by being grazed, and they may also be less vulnerable to drought if they are kept small. It is probably true that neither side of the border is producing fodder at the optimum rate, as defined in this way, the Negev being undergrazed and the Sinai overgrazed. The point is that the more desert-like Sinai is not necessarily the less productive of the two areas.

It has often been maintained that the most widespread problem on pastures in East Africa is not their complete denudation, but their invasion by thorn scrub. Shrubs and trees benefit when the removal of grasses by grazing reduces the competition for water (Pratt and Gwynne 1977). The invasion of thorn scrub increases biomass, and would appear on satellite imagery as an increase in vegetative cover (hence negative desertification), but is a loss in productivity for people on the ground.

Finally, if only to show that these processes are not confined to the Third World, there is the case of vegetation change in the South West of the United States. As in East Africa, cattle here have grazed down grass. This has allowed the invasion of pastures by the thorny, and (to cattle) unpalatable mesquite (Prosopis juliflora). Although the change in the character of the ground-cover encourages dune-movement, it may actually register on satellite imagery, and perhaps on the ground, as an increase in biomass, and therefore, in a simple system of classification as negative desertification (Wood et al. 1987).

The UN and Dregne definitions of desertification, mentioned above, seek to avoid the problems raised by these examples by using range classes. They assumed that a poor range class would have been assigned to all the kinds of degraded pastures in the

examples. Whether or not the authorities concerned could be relied upon to make these judgements, the main question that arises is: why call "desertification" a process that is clearly not the creation of more desert-like conditions? Why not use desertification to mean simply the creation of deserts? Perhaps even more serious: can it be assumed that any of these processes of change in pastures damage resilience? Are they relevant to the argument at all?

Soil erosion by water is a serious threat to agricultural and pastoral productivity, and although it occasionally results in total devegetation (i.e. desertification), its effects on productivity are usually patchy and subtle. Soil erosion by water is not a process typical of deserts. The rate of soil erosion by water, even on areas covered by natural vegetation, is greater in areas of higher mean annual rainfall (Walling and Webb 1983). On bare fields, the rate is many times magnified, so that it is a much more of a threat to agricultural fields in wet than in dry areas.

The most glaringly inappropriate process to label "desertification" is waterlogging, and yet it is included among the UNEP list of the processes of desertification. It afflicts many irrigation schemes. As a threat to world food supplies, it is one of the most serious threats to the resources of semi-arid and arid lands. The two processes - waterlogging and salinity - are symptoms of the same form of resource misuse - the overwatering of irrigated land - not a desert process.

These hazards to agricultural productivity attracted attention quite independently of the desertification campaign, and many years before desertification gained currency. The most serious effects of each one is to reduce productivity rather than to create total deserts, though in the extreme most can lead to desert-like conditions. Each has its own considerable literature and professional organisation. To term them desertification is unnecessary and confusing, and the case for subsuming them in the anti-desertification campaign is obscure.

The question that is begged by this tale of issue-fudging is: whose interest is served? Why not use terms that are less confusing in their locational connotations, and ones that are easier to define and measure than "desertification"? We answer these questions in the next section.

INSTITUTIONAL FACT, BLAME, TABOO

The idea of desertification does have its uses. The emotive image of sand dunes burying agricultural land is seen in some quarters to be a ready way of attracting attention, and it is hoped, funds. We will look at this argument through three "windows" (institutional fact, blame, and taboo).

Desertification as an Institutional Fact

Desertification has become an "institutional fact" as defined by Thompson et al. (1986). It is probably a rather better example

of the phenomenon than the one they used. Thompson defined an institutional fact as one that an institution wanted to believe, one that served its purposes. He found that while most of the institutions concerned with the Nepalese Himalaya maintained that soil erosion was a serious problem, both for local farmers and, through its effects on flooding, for residents of the Ganges plain, they did so in a factual vacuum: there were few reliable data. The statistics that were used by these institutions could easily be shown to be contradictory and unreliable. The reason for using these "facts" appeared to be to maintain the institutions, or the flow of aid to the Himalayas. The parallels between the Himalaya and desertification are striking. Another glaring example of desertification being used as an institutional fact is the following:

> On August the 4th, 1984, the late President Kountche of Niger urged his countrymen to join "the fight against the advancing Sahara" in order to avoid the humiliation and disgrace of desertification. He used the occasion to crack down on merchants who stole food-aid and slack civil servants, and to sack 30 traffic police. On April the 15th, 1985 in announcing even more draconian measures against desertification, he shelved plans to liberalize the domestic political system "in the face of the more pressing problem of how to feed the population.....', 'We cannot talk politics on an empty stomach,' he said. (He) called on Niger citizens to step up their fight against the advancing Sahara desert.....". (Agence France Presse). The idea of desertification was serving him well.

Blaming the Environment

Another insidious misuse of ideas like soil erosion in the Himalaya and desertification is their use to deflect attention from more sensitive political and social problems: to blame the environment, when blame should go to human institutions or individuals. Moving dunes often take the blame for degradation, where the serious problems lie elsewhere in the structure of the rural economy.

Desertification as Taboo

The final way in which the idea desertification serves political ends is when it is used as taboo. Riebsame (1986) analysed the ways in which land-use decisions had been reached in North Dakota up to the 1980s. Even though the State had never been considered part of the Dust Bowl of the thirties, the mythological power of the term "Dust Bowl" had quickly been appreciated, and had strongly influenced political thinking. By the 1980s the Dust Bowl had been renamed desertification, and many measures had been justified in its name, including the State takeover of some banks. The myth had also been kept alive as a means of attracting federal funds for North Dakotan farmers. Riebsame saw desertification as an ecological taboo that controlled political behaviour.

In their roles as institutional facts, whipping boys or taboos, imprecision of environmental concepts is an advantage; more precise notions would be open to test and disproof. We must emphasise here again (as we did when we discussed the statistics of desertification), that to acknowledge that the of desertification has been used for ulterior motives, is not to deny that there are problems in semi-arid areas. It may be that decision-makers can only work with concepts that appear greatly over-simplified to the scientist. Nevertheless, there are two counter arguments. Slavish adherence to a taboo like the dust bowl can fossilize opinion and act against clear thinking. Secondly, repeated use of unreliable statistics can be counter-productive. We maintain that only clear thinking and clear diagnosis of the problem will ultimately serve the people living in the dry lands.

TOWARDS DEFINITIONS OF DESERTIFICATION AND LAND DEGRADATION IN ARID AND SEMI-ARID LANDS

This section indicates only the broad guidelines for judging the problems we will be discussing. The discussion above has shown that defining desertification and evolving criteria have been very difficult. A large problem has been the failure to distinguish the commonsense meaning of desertification from land degradation. The distinction made, the task becomes somewhat easier, but still poses some problems.

Desertification is seen here as no more than an extreme form of land degradation, which occurs when the vegetation cover falls below about 35%, (with the proviso that resilience is borne in mind when assessing desertification).

Land Degradation Criteria for assessing land degradation should be clear, relevant, environmentally specific and scale-specific. With these guidelines, two broad criteria for judging land degradaton can be defined, based on the ideas of Conway (1984).

1. Productivity. By productivity is meant the rate of production. The distinction between productivity and production is important: production is merely standing crop, which is not of such interest to the producer as the rate at which the new crop is being produced, and this is productivity. A decline in productivity would be the most obvious sign of land degradation, but it would not be sufficient to establish degradation: a decline could have come about for purely social reasons, or it may have little to do with sustainability.

For relevance in this criterion, the product in decline must be identified, and be one that is economically important. Data may come from official statistics, from questionnaires, from sequential air photographs or satellite images, or from historical or archaeological research. Environmental Specificity may be difficult to establish: the causes of a change in productivity are not always obvious. It is necessary in each case to demonstrate that declining productivity is associated with an environmental change. This would exclude changes (such

as in the market), that could have extreme effects on people, but need not involve an environmental change. Scale Specificity needs to be defined first temporally; this enables the reader to judge if the period of measurement is too short (when the decline may not be degradation as meant here) or too long (when important shorter term changes may be missed). Second, the spatial scale must also be defined: the size of the area over which decline is said to occur (a field, a farm, a parish, a province, a country or a region). This is to avoid confusions about what is meant by decline: declining productivity on one small patch does not necessarily mean decline for a larger area, and vice versa.

2. Resilience is the property of a resource that makes its sustainable use possible. Land degradation occurs when resilience is damaged. The area over which damage occurs should always be stated as does a time scale , because in many cases resilience can only be seen to have been damaged if the system does not recover after a shock, such as a drought. The period of observation would then need to be at least one "drought cycle"; because of the uncertainty about what that might be, it is better to ask for data over a period of at least ten years. The resource in question should be specified in the interests of environmental specificity, and the measures of resilience should be as clearly defined as possible.

When we come to the relevance of resilience as a criterion of land degradation, we enter a very difficult area, for resilience involves more than environmental factors; it can only be seen in relation to a particular form of land use, and this should always be specified. The closeness of the relationship between the resilience of the land and the way in which it is used has been stressed by Parry (1986). We give here an illustration from the drylands:

> The way in which the Negev side of the Negev/Sinai border area has been revegetated after enclosure in 1949, seems to show that nomadic grazing over millennia has not damaged the ability of the pastures to recover; the pastures, by this account, are resilient to grazing, even if the system does not give optimum yields (Warren 1984a; Warren and Harrison 1986, and see above).
>
> But the environmental resilience revealed in this way is only relevant to pastoral nomadism of a particular kind. The mix of the external and local sources of bedouin income has always been changing, and each change in the economy has had repercussions on environmental resilience. After 1949 the loss of access to areas across the border for the bedouin in northeastern Sinai removed some of the external sources of income, and some of the seasonal and emergency pastures. This may have encouraged more intensive grazing on the remaining land: i.e. a change in land-use practices. The pastures may not be so resilient under this new form of land use. Only time will tell.

In short, the resilience of a piece of land or its loss of resilience must be assessed separately for every different form

of use (not merely grazing but grazing by specific breeds and these breeds managed in a particular way). Any investigation of the damage to resilience should involve continual iterations between examinations of the environment and of the economy, and between environmental, technological and economic opportunities.

Damaged resilience can of course be recovered: even the most degraded soil could be rehabilitated if large amounts of capital technology were available. An example can be taken from southern Australia (Williams 1974):

> In the early part of this century wheat yields from the sandy "mallee" soils were declining. At that time it appeared as if wheat farming was unsustainable, and the resilience of the soils was declining. But the discovery first of leguminous plants (bringing in nitrogen) and then of phosphatic fertilizers reversed the trends in wheat yields. Scientific and technological discoveries, and inflows of capital, had changed the form of land use, and the land use system was again sustainable, resilience having been restored.

There are therefore degrees of destruction: some lost resilience can be recovered easily; some is very hard to recover. This view differs from some of the definitions reviewed by Glantz and Orlovsky (1983), which demand that desertification should be seen as an irreversible change. Other definitions are more open to subtleties. Though Rozanov (1982), for example, maintained that desertification should be defined as an irreversible change, his definition is somewhat more complex:

> "Irreversible change is such a change of soil or vegetation that it requires either man's ameliorative interference or a very long (decades or even centuries) natural process for the restoration of the initial state."

The proposed definition in this paper is very similar; any damage to resilience is seen as land degradation. The degree of damage is gauged by the costs of recovering resilience. When the costs of rehabilitation exceed the benefits or the capital available for restoration, then land can be regarded as "permanently" degraded.

CLIMATE AND DESERTIFICATION

INTRODUCTION

The argument that climatic change has lead to increased aridity and so to desertification is both complex and controversial. The first complication is that it is difficult clearly to demarcate and monitor desert margins. A distinction must also be made between long-term, large scale climatic changes, and more localised reversible deterioration of the environment. Before considering the evidence for and causes of climatic change, an

attempt is made to resolve some of the confusion between the terms aridity, drought, desertification and land degradation.

ARIDITY AND DESERTIFICATION

Thompson (1975) explained that aridity, a lack of moisture, could be caused by four climatic processes: continentality, off-shore cold currents, topography and dynamic anticyclonic subsidence, and high pressure systems. Deserts are found where one or more of these processes operate over a significant area for sufficient time.

Aridity itself can be defined in several ways (Oliver 1973). Classifications of the arid lands of the world are attempts to take account of water deficiency through a combination of figures for mean annual rainfall, temperature and radiation budget over as long a period as possible. Yet it is difficult to establish climatic averages in the arid areas of the world because of the paucity of the data and the variability of the environment (Heathcote 1973). Hence care must be taken before pronouncing that there has been a trend of increasing aridity: this would have to indicate a 'significant' change in several, not always clearly related climatic variables.

Increasing aridity, caused by climatic change, is obviously a factor that needs to be considered when investigating desertification. Since "increasing aridity" can only mean a change in average conditions, and since climates in semi-arid areas are extremely variable, it could only be established with long periods of record. But even when such a record is available, one is still faced with the definition of "change in aridity".

First, and most obviously, drier conditions could be brought about by absolute reductions in mean annual rainfalls. Second, Parry (1987) argued that a change in climatic variability could be equally important: the mean rainfall could remain the same, but if the frequency of very dry years increased, then a land-use system might well be very stressed. Third, there could be a change in seasonal distribution: Dennett, et. al. (1985) showed that declining annual rainfalls in West Africa were primarily due to decreases during the month of August rather than the whole rainy season, and Degefu (1987) demonstrated that recent droughts in northeastern Ethiopia were mainly due to the failure of the spring rains. Fourth, desiccation could also be caused by land degradation: the destruction of vegetation and soil cover could lead to increased drainage and runoff losses and this in turn could lead to the suppression of rainfall. Finally, Glantz (1987) argued that changes to the effectiveness of the rain that does fall needs examination. Clearly a concept of aridity that only considered average conditions would be of little use in evaluating desertification. The term 'aridity' would be more useful if it measured variability through the whole of the hydrological cycle as well as climatic variations and fluctuations.

DROUGHT, ARIDITY AND DESERTIFICATION

If "aridity" is a climatic term concerned with average conditions, then "drought" refers to more ephemeral conditions which are abnormal and infrequent. It is nonsensical to see drought as affecting "true" deserts where very dry conditions are normal.

Drought, like desertification, is difficult to define, but whatever the definition, the term is widely used. "Drought" is often assumed to be caused simply by a lack of rainfall, i.e. a simple meteorological condition. For example, Dhar et al. (1979) defined drought, using the definition employed by the Indian Meteorological Office, to be a deficiency of 20% or more below 'normal' rainfall. It is true that definitions of drought based upon rainfall alone have the advantage of precision, and that rainfall data are often the only data available. Nevertheless, rainfall data reveal little about the effects on people. Sandford (1978) recognised this problem and suggested a more appropriate definition of drought:

> "A rainfall-induced shortage of some economic good brought about by inadequate or badly timed rainfall."

Some notion of a reduction in water supplies is essential to the definition, but the variability of the climate in arid lands suggests that the use of rainfall alone and in particular the use of annual totals is questionable. As the majority of the population is often involved in subsistence agriculture, an appropriate definition of drought might focus on the deficiency of moisture for crops, i.e. an agricultural definition. Krishnan (1979) reported the U.S. Weather Bureau definition as,

"A period of dry weather of sufficient length and severity to cause at least partial crop failure."

The term "drought" needs to incorporate a measure of the effectiveness of the climate for a specific purpose, be it the maintenance of an ecosystem, or of livestock herds. One should be able to define a "pastoral drought" or an "ecosystem drought" or a "millet drought". Drought would then be defined in terms of land use, and it follows that if the land use were to change, the frequency of drought would also change, without a necessary change in climate. Misunderstandings of the real meaning of "drought" can be seen to be the cause of much of the confusion about the crisis in the drylands. The question now becomes: has the climate changed, or has the occupation of marginal lands changed?

The widespread incidence of drought could then be a result of changing land use: it may throughout sub-Saharan Africa reflect increasing occupation of the semi-arid lands. It could also reflect desiccation of the environment through a reduction in the effectiveness of rainfall, by land degradation processes or climatic change.

CLIMATIC CHANGE AND DESERTIFICATION

In order to predict future climatic conditions one needs to:

1) Collect sufficient observations to illustrate spatial and temporal variations.

2) Establish trends and climatic changes.

3) Identify causal mechanisms.

4) Develop models that can predict future changes.

There is much uncertainty over the causal mechanisms of recent climatic change, and whilst sophisticated models have been produced, they do not yet give reliable and detailed predictions. Despite the growing evidence that global mean temperatures will rise because of the "greenhouse" effect, it has not been conclusively proved that people can so easily alter Earth's climate. Temperature changes aside, WMO (1983) maintained that it was unlikely that CO_2 concentrations had any effect upon increasing aridity. Changes in solar emissions might accentuate changes, but the effects of dust and any relationship with sea-surface temperatures was unclear. An increase in temperature would result in a rise in evaporation rates yielding more moisture to the atmosphere. There could be a corresponding increase in precipitation, but precisely where it would fall and the effect upon the subtropical high pressure belt remain uncertain.

Those interested in desertification are more interested in the incidence of droughts than in global climatic change, even if droughts do not in themselves cause desertification. The interaction between drought and desertification operates in two ways. Drought can precipitate land degradation by reducing water supplies in a system that is already imbalanced through overexploitation. Land degradation in turn may contribute to drought by feedback mechanisms involving surface albedo, soil moisture and possibly dust.

RESILIENCE AND VULNERABILITY

The characteristic of dry lands that makes them specially vulnerable is the slowness of recovery. Water is not available to re-weather rock and re-form soils, except slowly and in few places; or to wash away salts once they have accumulated; or to encourage recolonisation by plants once they have been removed or damaged; or to encourage the build-up of organic matter in the soil.

SOILS

Two types of dryland landscapes can be distinguished with different qualities of resilience: those formed by the wind and those formed by water.

Landscapes Formed by Wind Active sand dunes in very dry deserts are a considerable threat in some cases. The dunes are active in these environments not because there has been interference, but because there is too little rainfall to support plants, and because there are plentiful supplies of loose sand and strong enough winds. The dunes can be controlled, but at considerable cost, while the damage inflicted by moving dunes is not nearly as great as most of the other problems discussed here.

In semi-arid lands, on the other hand stabilized dunes are an important resource and their resilience is under real threat. The deposits cover about a third of the surface of most of the major semi-arid regions of the world. They were formed in arid phases of the Pleistocene, and became vegetated when the climate improved. The soils on these dunes support a high proportion of animal and plant production of many arid lands. They are useful soils for many reasons. Infiltration of rain is quick, and this and their depth contribute to their high available water capacities. The uppermost horizons of these soils dry out after rain, and this prevents the loss of water from deeper layers (Agnew 1982). These properties enable sandy soils to support more vegetation than most finer soils. They are also easier to cultivate, especially with the hoes and simple ploughs that are used by poor farmers. Their slightly acid nature is ideal for crops like groundnuts.

Cultivation is a much more serious threat to sandy soils than grazing. In most cultivation systems all the natural vegetation is removed, and resilience can be drastically diminished. It is probable that wind erosion has inflicted serious damage to the resilience of these soils: since the upper horizons of soils on stabilized sand dunes contain more silt and clay (and therefore potential fertility) than lower horizons (Pye and Tsoar 1987), and they also undoubtedly contain more organic matter. It is these upper horizons of course that are the first to be lost. Sandy upper soils usually allow rapid infiltration, and do not readily form crusts so that erosion by water is rare.

Landscapes Formed by Water Soils formed on landscapes shaped by water can in turn be divided into three distinct groups: on steep and gentle valley-side slopes and in valley bottoms. There is a characteristic, abrupt contrast between the virtual absence of soil on steeper slopes, and deeper soils on gentler ones. Soil erosion is thought by many authorities to be a very great threat to these soils on gentle slopes. Soil erosion is a serious problem on any soil if the rate of erosion exceeds the rate of soil formation. In hot wet tropical areas the rates of both are high, but in semi-arid areas both are probably low under natural conditions (Walling and Webb 1983). If erosion is artificially accelerated by clearing the vegetative protection, the rate of soil formation cannot keep up and soils are lost.

In all dry lands the most biologically and economically productive soils are in valley bottoms. Many authorities have pointed to the enormous contrast between the barrenness of most of the dry landscape and the lushness of life in these sites. Higher productivity arises mainly from the water that is fed down

to these low sites, but it is also partly a function of the depth of soil, and the nutrients brought down by the water. Valley floors are generally gently sloping, so that water erosion is not a great hazard. Moreover the soils, like loess soils, are deep, and able to withstand considerable loss from the surface. The two major hazards to these soils are waterlogging and salinity. Both salinization and waterlogging are a consequence of rising water tables. Waterlogging occurs when water tables enter the root zone and inhibit growth. Salinization may follow: when the watertable is high enough, there is capillary rise to the surface, and water evaporates there, leaving its load of salt. The salt inhibits plant growth by disturbing the osmotic relations in the root zone. Other problems associated with salinity are alkalinity and toxicity.

VEGETATION

Distinctiveness of Dry-land Vegetation

Dry-land vegetation, like dry soils is sparse, but, also like dry soils, it is very patchy. The small pockets of denser natural vegetation are crucial to grazing strategies: in extremity they are the standby, but they play critical roles even in good times. Unherded cattle in central Australia congregate in these spots, partly for shade (Pickup and Stafford Smith 1987), and in poorer parts of the world, herdsmen take their flocks there at night. The pockets, tiny as they are, supply by far the greater proportion of grazing.

Some of the Middle Eastern deserts where various vegetational provinces overlap are quite rich in plant species (Danin 1983), and the South African and Australian dry lands contain a fairly rich endemic flora, but in general, dry land vegetation is very species-poor (West 1982: Evenari et al 1986).

Dry ecosystems, according to Noy-Meir (1979/80) are characteristically pulse-response systems: rare pulses of rainfall activate an otherwise dormant system, and a low-intensity, rapidly attenuating wave of activity passes up the food chain. Because secondary producers must adjust to the poor rather than the rare good times (as in fact do many farmers), there are not always enough secondary producers to make use of the pulse of primary production after a rainstorm, and little of it is consumed under natural conditions. This means that graziers, who adopt their own strategies for maintaining the numbers of grazing animals, particularly mobility, can often make use of primary production that would go to waste in a natural system. This is one of the reasons why nomads can actually make more out of a semi-arid ecosystem than either natural grazing animals or ranching systems (Western 1982).

LOCATION AND TREND

In Africa, where data is hard to come by, attempts to quantify degradation, even in small areas, have so far failed to come up

with unequivocal proof that it exists (Ahlcrona 1988; Olsson 1985). As Olsson points out:

> "desertification, if such a process exists and can be defined at all, is such a complex process that a single indicator will not be adequate to represent the great number of interrelated components"

Assessment is clearly not easy. Some of the reasons for the problems have been mentioned already, such as:

1. Definition of Use. Assessment must be in terms of a specific use.

2. Assessment of Impact. It is often difficult to find out just what is the economic impact of degradation. Communities adjust in a complex way to degradation, as Parry (1986) noted.

3. Discovering Causes, whether natural or induced. Very often what appears to be degradation caused by interference is a natural part of the environment. The diagnosis of gullies and other signs of soil erosion is not at all easy. If interference is not to blame, then expenditure on restoration is unlikely to bear fruit.

4. The Episodic Nature of Erosion. Erosion events are infrequent and do not affect all of a landscape at once. The assessor may class something as degraded, when it is a mere passing phenomenon.

Whether the problem is worse in one country or another, or in one continent or another is even more difficult to assess than whether it is worse in one field or another. Two things can be said about international comparisons, however. First, richer countries have the skill, trained manpower and capital to restore land. These resources are not available in poor countries: the cost of restoration represents a much greater proportion of the national income, and is by that measure alone more serious. Second is the kind of impact. It is true that the effects of degradation on world food production are likely to be felt first through its effects on the highly productive farms of the rich countries. But, in terms of the effects on livelihoods, and therefore the more immediate impact, degradation will be felt first and most harshly in the poor countries, where population densities in the dry lands are higher and where more people are already close to the breadline.

For both these reasons it is in poor countries that the problem really lies.

If the location of degradation is difficult to determine, the trend is doubly so, as Sandford recognised (1983). To establish trends one needs sequential surveys, and yet methods of evaluations change, methods of land use change, and above all, the environmental is variable. Degradation is nothing new in history. It appears that many famines in the past were associated with land degradation, and accelerated soil erosion

has occured in the Old World since the Mesolithic (Blaikie and Brookfield 1986). Nevertheless, most authorities believe that the rate of degradation is greater today than it has ever been.

CAUSES

There is no shortage of blame for land degradation in the dry lands. Because our discussion of climatic causes concluded that they are not a major primary cause of degradation, the focus shifts to land use.

The Diversity of Degradation Environments

Degradation happens in many different contexts: in cool dry and warm dry environments; in very arid and semi-arid climates; and on different types of soil. More puzzling, it happens in very different societies; ancient and modern; advanced technologically, and traditional; rich and poor; capitalist and socialist and so on.

Explanations for degradation are never simple. Faults of technique and technology are linked to faults in society, and these in turn to faults in the world economic order. The explanation for degradation in any one place will be a complex mix of causes; overgrazing; overcultivation; population pressure, ignorance; greed; inequality; dependency; all act together in subtly different combinations.

Faults in Technique

Overgrazing. The definition of overgrazing depends on the practical interest in mind. To the nature conservationist it means the loss of valued species from the pasture; to a commercial, well capitalized grazier a pasture may be overgrazed if it is not at the optimum level of plant productivity; to a more ruthless, or less well endowed operator, who can still keep longer term in mind, it may be when the pasture reaches the "safe-capacity" threshold of Noy-Meir; or when unpalatable or less palatable plants begin to invade to the extent that there is little left to graze. To the desperate, poor pastoralist it may simply be when his goats have nothing left to eat. Overgrazing to a cattle-pastoralist may not be over-grazing to the goat pastoralist.

Many, if not most pastoralists, both ranchers and nomads, trade off mild overgrazing for other advantages: the need to keep the stock watered, the convenience of having them near the home; the belief that it is better to have a larger number of poor stock than a few well-fed ones.

Real anxiety is justified when large parts of landscapes become denuded, or when the most valuable grazings in valley bottoms are damaged. This kind of concern is now being expressed in Australia (Woods 1984), where it is based on a fairly secure country-wide assessment of damage.

Overcultivation. Overcultivation is a much greater menace than overgrazing. When the exposure of the surface by clearing for agriculture encourages loss of fertile topsoil or exposes infertile subsoil, then resilience is damaged. It may be inaccurate to assume that traditional systems of cultivation were perfectly at equilibrium with the environment, but the scale of damage, was certainly less in the past under lower population densities than it is now.

In eastern Sudan, the indiscriminate introduction of mechanised farming has led to the opening-up of large tracts of land which can then be eroded by the wind. The same has happened in parts of Iran (Schulz 1982). In West Africa, overcultivation has resulted from the need to maintain the value of exports of cash crops such as groundnuts in the face of declining world prices (Twose 1984).

Where farmers are richer, there are other manifestations of overcultivation. The Dust Bowl of the 1930s in western Kansas, and parts of Texas and Oklahoma, has been attributed to the introduction of mass-produced heavy farm machinery: ploughs, harrows and rollers. Today techniques like minimal cultivation have reduced the incidence of wind erosion. The wholesale ploughing of the virgin lands in the USSR in the 1950s and 1960s in response to Kruschev's call to increase food production, also used heavy machinery, and brought about wind erosion (Brezhnev 1978).

We believe, along with many others, that poor cultivation techniques play one of the most important roles in degradation in the dry lands. They are certainly the most extensive form of degradation (see Wood's survey 1984).

Faults in Society

Blaming technique and technology, however, is almost as pernicious as blaming the environment itself: it evades the issue. Why are people driven to adopt damaging methods of using their environment? This is a much more complicated and sensitive question, and one that many would rather avoid.

The first reason that springs to mind to explain why people adopt poor techniques might be ignorance. If pastoralists were simply told how their stock damaged the resilience of soils, and how to avoid this, or if cultivators were told to rest fields for several years rather than cultivate continuously, or to use manure, then might land degradation not be stopped?

It cannot be denied that people sometimes damage the resilience of dry lands through ignorance, but many of the claims that ignorance is to blame are suspect. For example, a belief grew in the 1950s and 1960s that nomads behaved irrationally. However, more recent research has shown, quite on the contrary, that they were usually a deeply rational part of a complex strategy of dealing with life in an uncertain environment (Dyson-Hudson, 1980; Jacobs 1975).

The main problem with accepting ignorance as a major explanation for degradation is its sheer unlikeliness; how could it be that ignorance has led to degradation only in the recent past? Surely their survival alone is testimony that these people have evolved a sustainable system.

Population

The human population has undoubtedly been growing in many dry lands. One of the first reports of "desert spreading" in English was about a part of Sudan that had seen an increase in population *following the return* of the Ansar (the Mahdi's followers) to their lands in Kordofan (Stebbing 1953). The pressure in Sudan appears still to be growing, to judge from the growth in area of cultivated land (Hellden 1978; 1984). Nevertheless, a little caution is needed with the explanation.

Studies of degradation, even in Africa, have not found it easy to relate population densities to degradation. For example, in the same part of Sudan to which Stebbing *(1953) referred, Olsson* (1985) could find no correlations between population data and degradation.

There are the repeated reports that, among pastoralists at least, growth rates in dryland populations are not high (Swift 1982). Nomads, it is suggested, adjust both the supply side (their milk and meat) and demand side (their own population) to the carrying capacity of the land. They can do this because they do not need a large or growing population to manage their herds. They control population by various birth-control methods, mainly social institutions, but also by emigration. If there is population pressure on pastoral lands it probably does not come from the pastoralists themselves.

In some areas, *the problem may be rather a decrease*, or a selective decrease in population than an increase (Kates et al. 1977). Much of North Africa and parts of West Africa have lost their active male population to work elsewhere and those who remain are less able to manage the environment. In the developed dry lands, degradation has been occurring in the face of a distinct decrease in the human population. In these areas the population is ageing, and an ageing population has less interest in the future of the land (Heid and Clawson *1965). Finally, as* in so many of these explanations, the "population" explanation, though it may be correct in part, can divert attention from more immediate causes.

Common Property Resources

Garret Hardin's (1968) provocative articles about the use of the world's resources provoked a debate about the role of commonly held property in resource degradation. Hardin himself believed that if a pastoralist owned his stock individually, but his land communally, it would be in his interests to overgraze; he would gain in the short run, society would lose in the long run.

It is probably true to say that in fairly stable and secure

traditional societies, common property resources are managed carefully and are conserved. When societies are under stress, either from external political or economic pressure, or from climate, or when their control over the range as a close-knit management group is removed, say by the nationalization of rangeland (Swift 1982), then the individual has little choice but to make the best he can of what is available to him, and Hardin's rule begins to operate.

Inequality

The inequitable distribution of resources is held to blame for a very large proportion of land degradation by some researchers (Blaikie 1985; Blaikie and Brookfield 1986). People who have lost control over their land can have little interest in long-term resilience of the resource, and little power to influence it. The little support that has been given to agricultural development in the Third World, has almost all gone to large commercial producers and not to the small farmers who are those who perpetrate and suffer the worst degradation.

Nomadic pastoralists have faced increasing inequality in many parts of the world. Pastoral land was appropriated by colonists in French Algeria and British Kenya, and is being appropriated by cultivators in the Sahel (Horowitz 1975). Nomadic grazing land has been nationalised in all African countries (Swift 1982), and much of it has been taken for state-registered schemes, as in the mechanised agriculture schemes in the Sudan. It is the poorer land and resources that are left in de facto control of the pastoralists, and yet the better land was often crucial to the pastoral strategy.

If Blaikie's analysis of land degradation (1986; 1989) has a single explanation it is that it takes place in societies under stress. Of course stress is easy enough to find if one begins to look for it, and some searches for stress can yield rather facile results. But it is not unreasonable to point to the stress of drought and the effect of the stock-market crash in 1929 on the price of wheat that was associated with the Dust Bowl of the 1930s, nor to the stress of competition with the United States that lay behind the erosion that followed the ploughing of the Virgin Lands in the USSR in the 1952s and 60s. Nor is it unreasonable to point to the stress of low world commodity prices and drought on the Sahel and the Sudan in the 1970s.

Poverty: A Shortage of Capital

If a community is too poor to raise the capital needed for restoration of degraded land, then degradation is likely to continue and accelerate. This has been recognised in the United States for many years where it has been Federal policy for the state to provide the capital for restoration. It is now recognised by the World Bank to be a necessary policy in the Third World (Hopper 1988):

> "Poor people cannot easily postpone immediate consumption for future returns. Nor will they ignore the pressing needs of the moment if these can be met from their limited resources, even if the use of these resources jeopardizes their longer term viability"

Of all the explanations we have offered, this makes the most direct connection between poverty and degradation.

Conclusion

We conclude, that dry land societies have been under great pressure in the last few decades. Probably no one cause of degradation stands alone but if there is one that stands above the others it is that societies have been losing control in a fast changing economic and political environment.

THE WORLD SCENE

Colonialism and Imperialism

Almost the whole of the dry world has in the past been colonised or under some form of imperialism. The only major exceptions are the Chinese dry lands, and even there it could be argued that their relationship to the central Chinese government was at many times one of "internal colonialism". Colonialism and imperialism intensified the peripheral nature of the dry lands, and introduced other pernicious effects.

1. In many imperial situations, cash-cropping was forcibly introduced provide taxes to meet, among other things, imperial costs. Opium was grown in India, cotton in the Punjab and the Sudan, groundnuts and cotton in West Africa. These new crops forced out food crops, and when prices fell, encouraged farmers to plough up and plant increased acreages in order to meet their own costs, the new demands for cash, and the national demand for foreign currency.

2. Imperialism disrupted old political balances. In Niger, for example, when the French, not without difficulty, finally defeated the Twareg camel nomads, who had been the political controllers of the Sahel. Fulbe cattle herders and Hausa cultivators were able to move into drier areas than they had settled before.

Inexperience

By "inexperience", we mean the poor understanding of the dry world by outsiders who have sought to interfere in it.

The dry lands were the frontier for nineteenth and early twentieth century Americans, Europeans and Australians. They entered unfamiliar environments, whether in their own "backyards" or in the colonies. They knew little about appropriate methods for using the new environment, and had little understanding of

how it behaved. They had no comprehension of its variability, or even of the dimensions and basic causes of aridity.

The second manifestation was scientific misjudgement. The early theories of range management stemmed from the writings about climax vegetation by scientists like Clements (1924), who were still only scratching the surface of an understanding of dryland ecology. In East Africa, hasty scientific or pseudo-scientific judgements about nomadic communities led to some disastrous administrative decisions (Baker 1977). In general, scientists rushed to condemn nomads as irrational, without any real study of the complexity of their ecological strategies (e.g. Lowdermilk, 1960).

The truth is that dry lands are probably the least well understood environment on Earth. Very little research has been into crops like millet and sorghum which are the staple foodcrops of the semi-arid lands (World Bank 1984). The huge problems of the dry lands, in Africa at least, are receiving pitifully little research. When the focus turns to research specifically into land degradation or desertification, the picture is even bleaker.

CONCLUSIONS

The causes of land degradation are more in society and the world economic order, than in nature. Ignorance in land users, but more in planners and scientists has been a strong component of the process. Among land users the blind spot may be the, to them, distant future. Among planners the failure has been more poor conceptualization, than lack of facts. The facts can only be collected after clear conceptualization. Moreover a coherent campaign must depend on clear goals, themselves based on credible facts. The most important factor to overcome in a programme to combat the problem of degradation is the economic imperative that drives people to degrade land, and the economics that prevent restoration and encourage a continuing spiral of degradation. Economic forces are linked closely to political ones; what poor people living in the dry lands need is control over their economic future. When this comes, they will demand to know how to manage their land so that it is resilient.

SOLUTIONS

The choice of solutions for the problems of dry lands depends, needless to say, on the analysis of causes.

There is no one set of solutions for all dry lands. Each dry environment, and each dry-land culture needs its own mix of policies. The first requirement in any plan is for careful study of the local situation, and careful sampling of the opinions of those who live and work in the local environment.

Dry lands have distinctive economics: returns per acre are very low; returns per man may be high. The distinction has always

been the appreciated by nomadic pastoralists, and by hunters and gatherers in dry lands, both of which value hands above lands (Swift 1982).

Risks are much greater in arid than in humid climates, and all dry-land planning has to take risk into account. Risk-mitigation is central to many policies for dry lands (Heathcote 1986): helping graziers and farmers over bad times by removing surplus stock from the range in droughts: bringing in extra food for cattle and people etc. Risk, however, is a matter of perception, and different circumstances produce different assessments of risk. A rich capitalist may be able to take a very big risk in an investment in dryland ranching, if he is remaining sources of income are secure.

RESEARCH

The period since the 1977 World Conference on Desertification has shown that very little is known about the processes of desertification and land degradation themselves, let alone about how the can be controlled. Basic research must precede the monitoring that is such a popular cause among the desertification organizations. We cannot know what to monitor if we don't understand the basic processes, and their impact on people's lives. What the stories of failure do suggest is that research hs been misdirected in the past. Research now needs to be both more scientific, and more applicable. Moreover, even if it is true that enough is known to begin the rehabilitation of drylands, it is doubtful if there is enough scientific knowledge and technology to sustain the improvement, and then to go on to create prosperous dryland communities.

We believe that there are four priority areas for research:

1. Research into the basic processes of land degradation, to include climatic data collection and climatic modelling research into the ways that semi-natural ecosystems maintain themselves, and how they change under use and achieve new kinds of equilibrium. More needs to be known of the role of soil-erosion in land-degradation; its effects on resilience and sustainability. This means research across the borders of natural and social science.

2. Surveys (monitoring) of desertification or of land degradation should be made from time to time, but they can only become valuable once the basic processes and values of degradation are understood.

3. Social research into how communities decline, survive or adapt. Knowledge of this kind is essential if there is to be any external influence on the future of the drylands.

4. Agricultural research of all kinds, but only agricultural research that is backed up by efficient extension.

EDUCATION

Education can play a role in rehabilitation. Agricultural colleges and agricultural extension work have played a crucial role in preventing land degradation in many parts of the dry developed world. There are many simple, cheap ways of maintaining resilience, and many skills to be learnt.

The main problem with an approach that puts too much faith in education is that it could be yet another way of avoiding the real issue. Unless education is part of a package, it can easily be irrelevant. The principal problems lie elsewhere, and until they are tackled, education could even be harmful. Until land users have the economic and legal freedom to control their future, and to apply and adapt the lessons they are taught, education about conserving resources can have little relevance to them.

ENCOURAGING AN "AGRICULTURAL TRANSITION"

There are at least three elements that appear to make for successful agricultural transition: democracy; bottom-up approaches; and giving emphasis to agricultural production. What is less clear is whether they are all necessary.

The successes achieved in the Mid-West of the United States and in semi-arid Australia in combatting degradation were those of societies in which the farmers had a considerable (some would say even too powerful) voice. This suggests that democratic institutions are important to recovery.

Most development specialists now believe that only small-scale schemes will work. In these, technicians trained in a wider view and in modern techniques work side-by-side with local farmers, so that there is mutual adjustment of indigenous and exogenous techniques to the problem in hand. More than this, though, central government and international agencies need to be persuaded that people will only react positively to development schemes if they are given much more control of them; particularly control over land, water and marketing. There are now many schemes in the dry world that are trying to meet these criteria, though their progress has not always been easy (e.g. Swift and Maliki 1984).

There are many obstacles to this kind of progress, nonetheless. In spite of a massive change in direction among African Governments and aid agencies in the last few years (e.g. CEC 1986), there are still governments who cling to ideas of central direction. The kind of restructuring that is demanded, and the transference of power from the cities to the countryside, are considered real threats to many regimes (Cater 1986). However, we believe this to be the only way forward.

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