

POPULATION, SOCIETY AND  
DESERTIFICATION

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## 1. INTRODUCTION

1. The hot deserts of the world, the areas of little or no vegetation, are natural phenomena. Desertification, the aggravation or intensification of such conditions, is a human phenomenon, arising most commonly from society's search for secure livelihoods in dry environments. In most instances this search proves successful. In others it involves destructive processes in which the productive base deteriorates and the social system is imperilled. Unlike drought, which is usually a short-term diminution in available moisture (1-5 years), the physical processes involved in desertification are long-term, chronic, and pervasive: dune and sand encroachment, degradation of vegetative cover and resources, soil erosion, and, where irrigation is used, waterlogging and salinization. Although distinct from short-term fluctuations, these long-term processes are intimately affected by them. Wind, storms, and drought greatly accelerate chronic destructive conditions.

2. The simple definition of desertification, which views it as the spread or intensification of desert-like conditions, provides us with a gauge to measure this destructive process, but tells us nothing about its causes, its dynamics, or its human consequences. Rapp (1974) has attributed desertification to a combination of drought and poor land use. However, the origins of desertification appear to be much more complex.

3. We see desertification as arising from interaction (Fig. 1) between the three major livelihood systems of the dry lands (agriculture-based, animal-based, and urban-based) and a combination of fluctuations in the natural environment and changes in human social systems at varying scales. Often this interactive process acquires a synergistic quality, as in the instance of the Mendoza oasis, where the very remedies for desertification become part of the hazard's causal mechanism. While each livelihood system possesses different characteristics and is exposed to varying degrees of vulnerability to desertification, in dry lands, in addition to fluctuations in climate, two major processes of human change

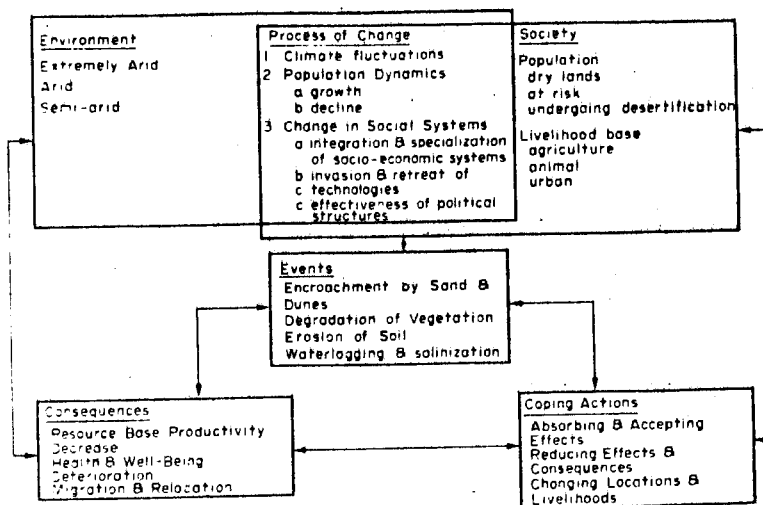


Fig. 1. Coping with desertification hazard

characterize the causal component of this interaction: (1) population dynamics is an important part of the process, for both growth and decline in population appear to cause desertification; and (2) three types of social change also contribute to desertification: integration into wider socio-economic systems alters the dynamics of local livelihood systems; the invasion of new and the retreat of old technologies truncates the evolution of indigenous expertise; and the fluctuating strength and effectiveness of governments drastically affect stability and survival in the dry margins. Out of these interactive processes develop the events that lead to desertification. In turn, these events give rise to desertification's salient consequences: deterioration in health and well-being and migration. And finally, societies respond to desertification with a variety of coping mechanisms whereby its effects are absorbed or accepted, its consequences are reduced, or its pressures are translated into change in livelihood or location.

4. Seventy-eight million people live in regions that have experienced severe or very severe desertification; of this number, 50 million are directly affected. In addition, the pressures produced by desertification affect a larger, but indeterminate, population as demands are placed on their resources for the support of less fortuitously located populations. For those populations directly affected, the human consequences of desertification are primarily twofold: the threat to the health and well-being of individuals and groups placed at risk by desertification and the problems and opportunities that arise from desertification-induced migration and resettlement. The threats to health and well-being arising from desertification are not easily identifiable as to cause and effect, but are reflected in the inadequacy of diet, the decrease in nutritional status, and accompanying vulnerability to disease that characterize declining resource productivity. Migration and relocation occur when livelihoods can no longer be sustained within weakened production systems and this entails both new opportunities and additional health, psycho-social, and economic problems.

5. Human societies are not merely passive recipients of the harmful effects of desertification. All peoples possess coping strategies enabling them to bear, reduce, or modify the consequences of natural hazards. These strategies may be deeply ingrained in the social fabric or they may be recently adopted innovations. Although they play a crucial role in people's survival, these coping strategies are not yet fully understood or, in many cases, even recognized. Adjustments to short-term fluctuations such as drought are relatively easy to document and this fact is reflected in a substantial body of literature dealing with human response to drought (e.g. Berry and Kates, 1972; Glantz, 1976; Heathcote, 1969; Kates, 1972). Desertification, on the other hand, has had little comprehensive study (the work of LeHouérou, 1968, and Rapp, 1974, comprising notable exceptions) and is a long-term process difficult to detect in short-term field study. Further, the more successful of society's mechanisms for coping with a long-term process such as desertification may be so embedded in everyday livelihood activity that they are no longer easily distinguishable as discrete coping strategies.

6. In spite of the existence of coping actions by societies affected by desertification hazard, much room is left for additional, especially international, effort. However, these efforts cannot succeed without a clear understanding of how desertification is both cause and consequence of change in the human occupancy of dry lands. Isolated from the context of regional, national, and global change, an understanding of the desertification process will prove to be illusory. The demographic, social, and behavioural aspects of desertification can only be seen in the perspective of continuing change in the lives and

livelihoods of the 628 million people (1974) who live and work in the dry lands of the world. For these peoples, desertification serves to accelerate changes already taking place in their lives, and, in turn, is exacerbated by them.

7. The will and wisdom of many nations will now concentrate on ways to combat desertification and ameliorate its effects. Such efforts, if they are to prove practicable and successful, need to be rooted in a basic understanding of the interaction of natural phenomena with social process, of the dynamics of how humans cope with environmental hazards. This review provides a framework for understanding these dynamics. It sets forth the numbers and patterns of human occupancy of dry lands, a simple typology of life and livelihood systems, within which we will trace both the causes of and the processes of change instituted by desertification. In this wider context, we can examine the vulnerability of peoples and livelihood systems to desertification, the various modes of coping with the hazard that exist in different livelihoods, and the implications for action that flow from these understandings.

## II. POPULATION AND LIVELIHOODS AT RISK

8. No assessment of desertification and the prospects for ameliorating its effects is complete without an understanding of the human populations placed at risk by environmental and social change. This section explores the basic demography of different dryland countries, examines the major livelihood adaptations to aridity, compares the relative vulnerability of these systems to desertification processes, and estimates the magnitude of the population placed at risk by desertification.

### A. POPULATIONS OF THE WORLD'S DRY LANDS<sup>1</sup> AND REGIONS UNDERGOING DESERTIFICATION

9. Approximately 14 per cent of the world's population, 628 million people, live in the dry lands. Of these, the majority, 72 per cent, live within semi-arid zones, 27 per cent inhabit the arid zone, and 1 per cent live in the extremely arid zone. Rural population densities vary according to the productivity of the micro-environment, but they generally remain below 1 per square kilometre in the extremely arid zones, below 5 per square kilometre in the arid zones and below 10 per square kilometre in the semi-arid zones (see Table 3). However, densities are considerably greater wherever irrigation agriculture is practised.

10. Table 1 contains population estimates by livelihood groups for the dry lands. Since demographic data are of doubtful accuracy for many of the countries, the figures should be read and used with caution. Even more problematic are livelihood estimates for nomadic populations which can vary by a factor of from 2 to 8 depending on the criteria used (US, CDC, 1973, versus Berg, 1975). Another problem is the urban population estimate, which appears to be too high. Some national censuses accord urban status to places with as few as 500 inhabitants, while others use a much higher threshold (Davis, 1969). A more accurate livelihood analysis might shift up to one-third of the urban population into the agricultural category. On a world scale, the result of this modification is a dry world population that is 21 per cent urban, 72 per cent agricultural, and 7 per cent animal-based. Despite the many necessary qualifications, this estimate can serve as a basis for examining the relative vulnerability of dryland people to desertification.

11. Of the 628 million people inhabiting the world's dry lands, approximately 78 million presently live in areas undergoing severe or very severe desertification. These figures are summarized in Table 2. According to Dregne (n.d.) severe desertification means that resource-base productivity is threatened, while very severe desertification indicates that the deterioration is so acute that it is economically irreversible. Not all of the 78 million inhabitants of these areas are directly affected by desertification, since occupation or economic status may provide a shield against the hazard. Nonetheless, it seems reasonable to assume that a majority of this population experiences some of desertification's adverse effects.

<sup>1</sup> Dry lands is here used as a comprehensive term for Meigs's (1953) threefold classification of the world's rainfall-deficient regions into extremely arid, arid, and semi-arid.



TABLE 1. *Estimates of dryland<sup>a</sup> populations by region<sup>b</sup> and livelihood group (in thousands)*

Region	Dry lands Total population <sup>c</sup>	Livelihood populations in dry lands		
		Urban based	Agriculture based	Animal based
Mediterranean Basin	106,800	42,000 (39%)	60,000 (57%)	4,200 (4%)
Sub-Saharan Africa	75,500	11,700 (15%)	46,800 (62%)	17,000 (23%)
Asia and the Pacific	378,000	106,800 (28%)	260,400 (69%)	10,300 (3%)
Americas	68,100	33,700 (50%)	29,300 (43%)	5,100 (7%)
	628,400	194,200 (31%)	397,100 (63%)	37,100 (6%)

<sup>a</sup>Meigs's classification (1953) including extremely arid, arid, and semi-arid areas.<sup>b</sup>Groupings as designated by UNEP Governing Council for regional meetings.<sup>c</sup>Total world population was estimated to be 3.86 billion in 1974.

12. How many people make up this majority is difficult to define precisely. Using a different approach, this review estimated that 50 million people are exposed to desertification. Therefore, an overall vulnerability figure can be expected to lie somewhere between 50 and 78 million. In areal terms the problem also is significant, for Dregne's categories cover an area of 30 million square kilometres, or 22 per cent of the dry lands as defined by Meigs (1953). The populations inhabiting these areas account for 15 per cent of the total dryland population. Significantly, this population is differentially exposed to desertification. Animal-based populations are only 6 per cent of the total population of dry lands, yet they represent 22 per cent of the population threatened by desertification.

TABLE 2. *Estimates of populations and livelihoods resident in areas recently undergoing severe desertification<sup>a</sup> (in thousands)*

Region	Total population	Urban based	Agriculture based	Animal based	Area (km <sup>2</sup> )
Mediterranean Basin	9,820	2,995 (31%)	5,900 (60%)	925 (9%)	1,320,000
Sub-Saharan Africa	16,165	3,072 (19%)	6,014 (37%)	7,079 (44%)	6,850,000
Asia and the Pacific	28,482	7,740 (27%)	14,311 (54%)	6,431 (19%)	4,361,000
Americas	24,079	7,683 (32%)	13,417 (56%)	2,979 (12%)	17,545,000
	78,546	21,490 (27%)	39,642 (51%)	17,414 (22%)	30,076,000

<sup>a</sup>As estimated by H. Dregne (includes both severe and very severe categories).

### B. DRYLAND LIVELIHOOD SYSTEMS AND THEIR RELATIVE VULNERABILITY TO DESERTIFICATION

13. Faced with the need to derive sustenance from dryland environments that are hazard-prone, harsh, and capable of great interannual fluctuation in productivity, people have evolved an array of livelihood systems. These livelihoods not only enable survival, but also produce usable and desired products, many of which are exported to more humid regions.

14. Within each major livelihood system, agriculture-based, animal-based, and urban-based (see Fig. 2), further subdivisions can be distinguished, each possessing its own demographic characteristics, technology, social organization, and behavioural traits. These livelihood systems do not operate in isolation; rather they are complexly interlinked and interdependent. Most culture groups do not rely on just one exploitive system, but instead utilize a dynamic mix or complex of techniques. Over a period of time complementary

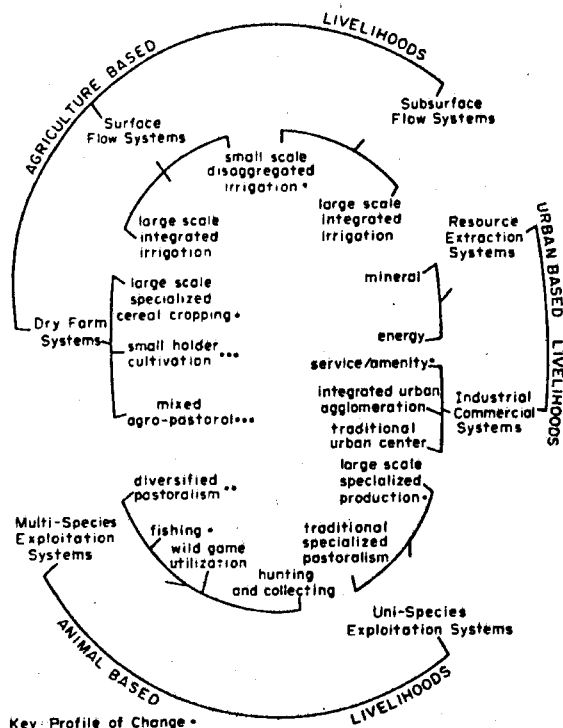


Fig. 2. Livelihood systems in dry lands

sets of activities have evolved that spread the risks inherent in dryland environments, maximize productivity to the extent that available technology permits, and meet cultural and economic ends.

15. At the same time, these adaptations are not without their problems, for as local systems become increasingly integrated into national and international market economies, they become exposed to forces operating beyond their boundaries. In today's world economy where prices, marketing structures, and political events integrate the most disparate groups, it can be said that no culture stands alone, timeless, changeless and self-sufficient.

16. These relations between the world market economy and the three basic livelihood systems are mediated by the concrete conditions operating in different nation states. Therefore, a generalized vulnerability assessment based solely on livelihood systems is at best too general to be useful in specific cases, and at worst misleading. However, the world market economy is such that it is composed of two basic categories of nation states: developed industrialized countries, and developing countries. If this criterion is taken into consideration along with that of livelihood systems, then certain basic parameters of vulnerability to desertification can be outlined. Additionally, patterns of land ownership and the distribution of wealth come to bear upon the differential vulnerability of groups within a society. In the following pages an attempt will be made to incorporate these elements in an assessment of livelihood system vulnerability.

### 1. Agriculture-based Livelihoods

17. Two basic types of agricultural livelihood exist. One relies on dry farming (rainfall dependent) techniques and the other employs irrigation technology of varying degrees of sophistication and at differing scales. Together these livelihoods account for 5 out of every 7 people inhabiting the dry world. Here are found some of the highest birth and death rates among dryland peoples, with population generally growing at a rate of 3 per cent per annum. It is mostly from this sector that the ranks of urban migrants are swelled.

18. Dryland farming, the most prevalent livelihood in the semi-arid zones, is characterized by a range of strategies and techniques enabling farmers to cope with a high degree of rainfall variability. Except in so far as they relate to people's vulnerability to desertification, a full description of these strategies is beyond the scope of this review. (See the companion review on Ecological Change and Desertification for full coverage of this material; Warren and Maizels, 1976.) In this regard, two basic categories of dry farming strategies are of interest. The first category is smallholder cultivation which largely emphasizes strategies that permit moisture maximization within field systems. The second category involves strategies combining cultivation with gathering and/or animal husbandry. Both moisture maximization and mixed agro-pastoralism provide the livelihood with needed flexibility and diversity enabling maximum security within uncertain rainfall régimes.

19. Moisture maximization, particularly in non-industrialized developing settings, involves an array of diverse techniques that include: careful seasonal plantings of fast-maturing varieties, scattered plantings of drought-resistant crops, careful weeding and mulching practices, the use of moist bottomlands, and the construction of terraces, bunds and dams to impound run-off water. In terms of desertification, it can be said that most of these moisture maximization techniques are either benign, or actually conservative of soil and soil fertility. For example, the primary objective of ephemeral stream dams and hillslope terraces is to trap run-off from infrequent rainstorms. In the process, these structures also act as a means to impound soil and organic material carried by the run-off, thus providing fields with a renewable source of fertility. This technique not only enables cropping under circumstances which otherwise would not be appropriate to cultivation, but, in fact, also can support relatively high population densities. West (1970), for example, estimates that semi-terracing contributed substantially to pre-Conquest densities of up to 90 persons per square kilometre in Central Mexico.

20. Moisture maximization techniques such as terracing are labour intensive and therefore vulnerable to losses in manpower. As traditional societies increasingly become tied to an outside market, economy terrace extension and maintenance can suffer. Reports from sites as widely scattered as Mexico (Johnson Haring, 1976a), Kenya (O'Keefe, 1975), and Yemen (Dow, 1975) document a process of terrace degradation that is linked to labour out-migration. The full ramifications of this type of desertification are unknown, and its effect on socio-economic structures awaits investigation.

21. Most dry farming in developing countries combines cultivation with gathering, craft-manufacture, and animal husbandry. In most cases, these activities provide a crucial complement to an uncertain agricultural situation, thereby forming an integrated agro-pastoral production system. Mixed agro-pastoralism can take numerous forms. Let us examine two of these in order to assess their dynamics and consequent vulnerability to desertification.

22. In the first case, traditional mixed agro-pastoralism (Faulkingham, 1976; Johnson Haring, 1976b; Malhotra, 1976b; Wisner, 1976) combines the gamut of semi-arid resource-use activities in one household productive unit. Changes occurring in the larger national or international setting often render some of these activities economically obsolete. Handicraft manufacture, for example, is frequently replaced by industrialization. Handicrafts provide a key source of supplementary cash income for many dryland agriculturalists; therefore, when they are undercut a family must resort to other options. Increasingly they resort to labour out-migration. This, in turn, leads to a decline in field maintenance, and consequently in local productivity, thus further weakening the local system. The deterioration of field maintenance, as in the case of terrace systems, can lead to serious desertification. In other cases labour out-migration merely entails a deintensification of local cultivation with no irreversible damage to the productive base.

23. In the second case, mixed agro-pastoralism operates within a system composed of separate but integrated parts held together by a system of unequal interdependence in which restrictive land tenure patterns play a crucial role. This is the case where large livestock ranches and peasant share-croppers (e.g. Brooks, 1976) enter into an arrangement whereby landowners provide subsistence plots in exchange for the labour needed in the cattle raising operations. This system is prone to desertification when an expanding population is concentrated on marginal lands while the bulk of the land is devoted to extensive grazing. Overcultivation, accelerated soil erosion, and deforestation are the inevitable consequence of this arrangement.

24. Commercial dry farming in the industrialized world copes with rainfall uncertainty by means of strategies and support systems (e.g. government subsidies, insurance programmes) unavailable to peasant cultivators in the developing world. In this sense, their stability is assured in the short term (Bowden, 1976). The consolidation of farms into large corporate units using capital intensive production is frequently an important aspect of this stability. Capital and technology seem, at present, to be able to cope with problems of soil erosion and dune encroachment (e.g. Heathcote and Williams, 1976). Williams's review (n.d.) of the history of soil erosion in farming areas of South Australia suggests that periods of declining resource productivity were followed by the adoption of technical innovations that would allow recovery at higher levels of productivity (Fig. 3). However, the long-term success of such short-term stabilized systems is unclear. Escape from the pressures of the local physical environment are made at the expense of a dependence on market economy over which the producer has little or no control. In the

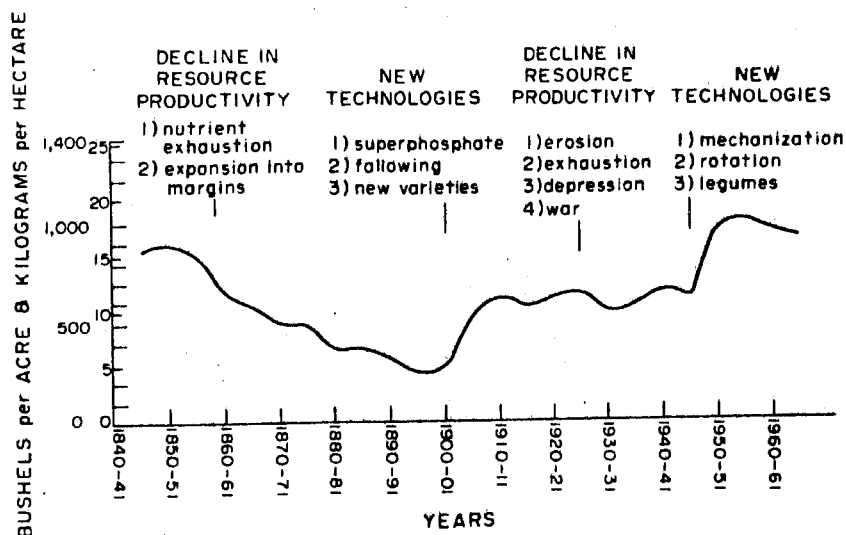


Fig. 3. Resource productivity and technological adjustments in commercial farming, South Australia

Australian Mallee between the wars, for example, profit margins were slowly whittled away as operation costs rose and unexpected market fluctuations changed anticipated profit into oversupply and sudden debt. The response was to seek greater economies of scale achieved through the use of more labour-saving technology with higher energy cost. Such changes may only delay a day of reckoning. In this sense, short-term success may initiate a process that ultimately increases long-term vulnerability.

25. The second principal agricultural livelihood in dry lands is based on irrigation. Irrigation often provides more secure support, but not necessarily greater resistance to desertification, than does dry farming. Irrigation results in the growth of dense population concentrations in the major riverine valleys of the arid lands. This growth is not without its own special problems, especially salinization, siltation, and periodic destructive flooding, but the regional disparities in population distribution within dryland countries can be explained largely on the basis of the high agricultural productivity potential of both modern and traditional irrigation systems.

26. Several basic types of irrigation systems can be identified. On the one hand are the systems that rely on surface flow. These include traditional systems based on annual floods inundating floodplain basins (either natural or man-made) which then serve as settling points for silt-rich alluvium. Success in this system depends in large part on the regularity of the annual flood. In the case of the Nile, an elaborate civilization and population developed without requiring massive investments in canals and other hydraulic works because the annual flood was extremely regular in both time and quantity. In most other instances, stream régimes were more irregular, requiring integrated canal systems to smooth out system irregularities and to bring water to areas normally beyond the reach of agricultural operations (Jacobsen, 1960; Walters, 1970; Adams, 1965). The development of urban civilizations is associated with such irrigation settings.

27. This system often, at least in its initial stages, resulted in desertification, since the rise of cities encouraged a concentration of population and an intensification of production close to the urban area with associated land abandonment in more peripheral

districts (Adams, 1974). The growth of salinization and siltation difficulties also characterized this era (Jacobsen and Adams, 1958). Continued growth of population in these rich alluvial environments has sparked interest in converting all such annual systems to perennial multi-crop enterprises. It is this drive that underlies the High Dam at Aswan and the Euphrates Dam in Syria. Yet all of these activities remain subject to desertification processes inherent in the system and, since they are all dependent on water derived from humid areas outside the arid zone, they all remain exposed to political and climatic events that might reduce the volume of water available. Moreover, salinity and waterlogging continue to plague modern irrigation systems. Often, it is inadequate provision of drainage facilities, as in the Mussayib project (van Aart, 1971), that leads to decreased productivity which can only be restored at great expense. Problems of salinization and waterlogging are not limited to developing countries. Warren and Maizels (1976) review examples of serious deterioration in irrigation systems of industrial nations. Where political boundaries are involved, as in the cases of the Colorado River flowing through the United States and Mexico, this problem can be especially intractable. Over the years, as agricultural use of the upper Colorado Basin intensifies and the salt content of the river steadily increases, the downstream users in Mexico have had a particularly difficult time in exerting control over the quality of the water they receive.

28. Somewhat less vulnerable to desertification are the point irrigation systems that tap groundwater. This generalization is especially applicable to the underground water collection galleries found in many parts of the Middle East (*qanat* in Iraq; *aflag* in Oman; *foggara* in North Africa). However, outflows of labour to economic opportunity elsewhere in the country may reduce the labour supply needed to keep the system functioning. Shallow groundwater wells or agricultural systems using date palms to tap near-surface groundwater are also less vulnerable as long as overexpansion of the system is not encouraged. Deep bore wells may be productive in the short run, especially the central pivot systems that have replaced extensive ranching operations in Nebraska and provide a high technology alternative to the traditional oasis gardens of Kufra oasis in Libya (Splinter, 1976). Such systems are vulnerable to desertification wherever groundwater reserves are imprecisely known. Moreover, their dependence on high energy fossil fuels is a considerable risk in an era of rising energy costs and uncertain long-term supply. Deep bore wells may be productive in the short-run, but watertable depletion makes them prone to their own peculiar form of desertification.

## 2. Animal-based Livelihoods

29. A detailed review of animal-based livelihood systems is beyond the scope of this paper. However, a few important characteristics should be noted. The most significant feature of traditional animal-based livelihoods is their emphasis on mobility. It is by movement to seasonal pastures at different locations that the pastoralist is able to balance pasture and water through an annual cycle. To accomplish the same purpose, modern commercial ranching or game harvesting schemes usually must also incorporate large areas, but at a lower stocking rate. Western (1974), in comparing the food chain efficiency of various pastoral management strategies in the Amboseli grassland, found that Masai had a food chain efficiency of 12 per cent compared to the 6.5 per cent figure of commercial ranching operations. This is, in part, a reflection of the advantage obtained by the pastoralist's cattle since they are brought into contact with easily digestible young plant

growth for a longer portion of the year. While pastoral movement takes place for a number of other reasons, including escape from disease, access to markets, acquisition of farm products and religious devotion, a major factor is an ecologically astute assessment of seasonally variable pasture quality and productivity. Hunters (Lee, 1969) exhibit analogous patterns of movement that are linked closely to seasonally available water supplies, to the location of forage, and to animal movements that are related to available moisture. While fishing populations are more immediately restricted to the locale of their resource base, they are found wherever water is sufficient to support fish. Fishing people are important protein producers in dry lands (UN, FAO, 1975), and will move over great distances to take advantage of the fishing potential created by new dams (Lagler, 1973).

30. A second major strategy employed by animal-based populations is to diversify their livelihood systems. This is done in a number of ways. Pastoralists often herd a mixture of animal species in order to maximize the productive potential of the various ecological niches available to them (Western, 1974; Johnson, 1973). Hunters most commonly exploit a variety of game species, while fishing cultures (with only rare exceptions) rely on a mixed catch. Only under the most extreme environmental conditions where only the hardiest species survive, do pastoralists concentrate on one species. Commercial livestock ranching, which exploits a rigidly bounded space with herds of one species, stands in contrast to these principles of traditional animal-based exploitation régimes.

31. Thus the combination of mobility, flexibility, and diversity characteristic of traditional livelihood systems reduces their vulnerability to desertification and lessens their contribution to desertification processes.

32. Hunting populations are so small on the global scale that their contributions to desertification are insignificant.

33. Fishing populations are minor contributors to desertification; however, they are dramatically affected by its consequences. The case of the Mohanas of Lake Manchar in Pakistan, as documented by Hewitt (1976), illustrates the risk run by a fishing culture when its basic resource is diminished. As Lake Manchar shrinks, and finally dries completely, even such basic tools as the Mohanas' boats are threatened. Should present conditions worsen, this basic resource would be damaged beyond repair. Compounding the problem is the fishing population's small size and its relatively insignificant political power in contrast to competing water resource consumers. Just as water diversion for irrigation may permanently endanger Lake Manchar's status as a fishery resource, so, too, the migration of fishing populations to newly created dam sites is often resisted because of its potential for overloading the local fishing capacity (Henderson, 1974) to the detriment of the indigenous inhabitants. Moreover, the dams and irrigation systems developed to combat desertification, while opening up new fishing potential, can cause disproportionately greater alterations in the aquatic ecology of downstream areas. In the case of the Aswan Dam, the decline of productivity in both the coastal marshes and the deep sea fishing grounds may have exceeded gains in Lake Nasser (George, 1972).

34. The role of pastoral communities in desertification is not as clear cut. In one sense, pastoralists are somewhat less vulnerable to desertification than are agriculturalists. This is a consequence of their superior mobility, which permits accumulated capital reserves, in the form of animals, to be shifted to less affected regions. Possession of herds containing a number of species may ensure the survival of at least some animals in severe drought and permits a shift in herd composition to larger numbers of hardier species should an acute drought phase trigger a chronic decrease in productivity.

35. Yet if nomads are ecologically less vulnerable than sedentarists, they are frequently more vulnerable politically. Colonial boundaries often truncated ecological zones that, from a pastoral perspective, constitute one grazing system. Thus, the bedouin of northern Arabia found their grazing lands split among several countries, and analogous conditions can be found elsewhere (Cossins, 1971; Melamid, 1965). Governments controlled by sedentary groups of different ethnicity also serve to increase the marginality of pastoral groups, since distance from the centre, spatially and politically, often delays the input of aid until deleterious conditions are well advanced. Furthermore, economic returns to investment in agriculture often show a higher net return, prompting a greater flow of capital into non-pastoral areas (Western, 1974).

36. Nomadic populations have often been blamed for their presumed tendency to promote overgrazing. Conventional wisdom contends that a growth in human population is paralleled by an increase in animal numbers, inevitably accelerating pressure on the land and initiating a long-term downward spiral in productivity (EMASAR, 1975). Even a small steady growth in nomadic population should, therefore, result in more animals on the range since only in this way, in the absence of other employment, can a larger population be supported. Larger size herds per family are not required to postulate overstocking. However, many nomads settle spontaneously, reducing the pastoral population needing support from the animal economy. Moreover, herd composition often changes toward species that meet the food preferences of the growing sedentary population; such changes increase the pressure on certain fodder species while decreasing the pressure on others. The overall impact of these variables is being investigated quantitatively in southern Tunisia (UNESCO, MAB, 1975). It is also possible to find rangeland deterioration in specific areas at least partly as a result of increases in livestock. LeHouérou (1968) has reviewed the evidence for portions of the North African steppe and argues that a substantial decrease in primary productivity has taken place there. Peyre de Fabrègues (1971) points out the impact of excessive animal concentrations around watering points. Heady (1972) has described the island of degraded vegetation that rapidly develops around a newly sedentarized pastoral community, an effect that has been widely noted in the literature (Toupet, 1975; Shamekh, 1975; Darling and Farvar, 1972). Overgrazing pressures are as likely to come from an expansion of herds kept by settled agriculturalists or by the confinement of nomads to more restricted and marginal rangeland, as they are likely to stem from mismanagement by the pastoral community. For example, loss of rangeland and dry season fodder reserves in the Awash Valley to an expanding agriculture (van Lier, n.d.) and to hydroelectric power development accounts for much of the stress experienced by Afar pastoralists (Cossins, 1972). Political impotence leaves the pastoralist increasingly vulnerable to desertification and doubly maligned, as the victim is blamed for a problem not solely his responsibility.

37. Acute and rapid desertification is also found in commercial ranching. This frequently results when persistent wet periods coincide with unfavourable market prices. Herd growth stimulated by abundant pasture is only worthwhile if the price of meat remains high enough to make movement to market profitable. With depressed prices, ranchers are encouraged to retain animals on pastures that may only be temporarily productive. The experience documented in the Gascoyne case study (Williams and Suijdendorp, 1976) suggests that reversion to more normal rainfall patterns will be accompanied by both degradation of the rangeland and extensive animal losses. An excess of animals produced by precisely these conditions threatens much of interior Australia at the present time.



Commercial ranching schemes inserted into regions dominated by traditional pastoral systems can also lead to desertification. In these cases pressures are more apt to appear outside the fenced rangeland as traditional pastoral groups find their grazing areas restricted. On occasion partial implementation of ranching schemes that attempt to reshape traditional pastoral practices has resulted in desertification due to overstocking within fenced areas (Talbot, 1972). Even within well-managed livestock schemes in industrialized countries desertification can occur unless great care is taken to control grazing, and in the USSR it has been found that pasture rotation systems that in certain respects approximate the mobility principle of traditional pastoralists provide the best way to maximize productivity without rangeland degradation (Nechayeva, 1976).

### 3. Urban-based Livelihoods

38. Between 20 and 30 per cent of the population of the dry lands live in urban centres. However, it is difficult to estimate the proportion of this urban-based percentage that actually engage in non-agricultural production. Nonetheless, it is clear that the productive activities centred in dryland cities are qualitatively different from those of their hinterland.

39. Historically, dryland cities have served as commercial and administrative centres, have grown up around mines, have developed as ports and amenity centres, and, to a degree, have industrialized. Except in so far as manufacturing may play a lesser role than other functions, dryland cities are not fundamentally different from their counterparts in more humid environments. It is not in urban functions but in the interaction between dryland urban growth, with its associated consumption needs, and the arid environmental setting that the source of these cities' distinctiveness, as well as their possible vulnerability to desertification, is to be found.

40. In this regard it is possible to distinguish between two types of urban/arid environment interactions. The first type of interaction is *intrinsic*; that is, it relates to problems that might arise from any concentration of population in the arid lands: the need for fuel, shelter, water and food which may not be available in sufficient quantities in the immediate hinterland of the urban centre. In the developed world these needs are taken care of because the dryland city operates as a specialized component of a larger, modern system of exchange. In the developing world, where production, technology and supply networks have not reached this level of development, the needs of urban dwellers often must be satisfied by exploiting the local hinterland. Therefore, the need for fuel and firewood can often lead to serious deforestation around urban centres (Warren and Maizels, 1976). Cattle concentrations near cities can also devegetate large areas leading to soil erosion and the formation of localized dust bowls (Berry and Kates, 1972). In turn, devegetation and soil erosion can threaten limited water supplies by increasing reservoir infilling.

41. The second type of interaction arises from the *indirect* effects of drought or desertification taking place in the urban centre's hinterland. In this case the city becomes the recipient of a sudden, heavy influx of rural population. Except in the case of drought refugees, it is difficult to disaggregate rural-urban migration induced by desertification from that brought about by other pressures and temptations upon the rural sector. Nonetheless, urban centres located within regions experiencing desertification can expect a continued flow of rural migrants.

42. This migration has positive and negative aspects. For one, it is likely to entail the improvement in the lot of individual migrant families. For example, evidence from studies done in Lima, Peru, indicates that migrants are better off there than if they had stayed in the rural sector (Mangin, 1970). Another example shows that wages three times as high in Cairo as in the Delta underlie the movement of fellahin into urban employment (Abu-Lughod, 1961). Once a rural-urban flow is established, permanent links, complete with modest monetary remissions to the rural sector, often develop. There is some evidence indicating that this, in turn, may contribute to the underdevelopment of the peasant rural sector (Nolan, 1975). It should also be noted that larger urban populations create larger markets for rural produce and this allows farmers to make monetary savings.

43. The negative effects of heavy urban immigration in developing countries are obvious. Urban services, often inadequate to begin with, are further overburdened. The intrinsic problems of urban/arid environment interaction are exacerbated by burgeoning numbers of city dwellers. Water consumption rises dramatically leading, as in the case of Mexico City, to the diversion of agricultural water supplies for urban needs (Fox, 1965). This triggers desertification in the hinterland which, in turn, generates a new source of migrants. Similarly, as the demand for fuel increases in urban centres the radius of deforestation rings extends dramatically, and at the same time the cost of charcoal and wood rises for a population that can ill afford it.

44. The spectacular growth of some dryland cities in the developed world exhibits a different pattern. Amenities such as sun and mild winters attract large numbers of new residents to these centres (e.g. Wilson, 1976). In addition, the growth of service industries provides a healthy economic basis. Under these conditions, the dryland city can afford to import a large portion of its necessities. Except for the destruction of native vegetation in order to make way for suburban development, and for strains placed upon groundwater supplies, these cities appear to be viable in at least the short term.

### C. SUMMARY

45. Approximately 14 per cent of the world's population, or 628 million people, live in dry lands. Twenty-two per cent of this dry realm is exposed to severe or very severe desertification and 15 per cent of the dryland population inhabits these vulnerable areas. Thus, between 50 and 78 million people are directly threatened by desertification. However, vulnerability to the hazard varies considerably; economic status or urban residence shields many, while some livelihoods, such as the animal-based (who are 6 per cent of the dryland population but 22 per cent of the risk-prone population), are disproportionately exposed to risk.

46. All agriculture-based livelihood systems in the dry lands are potentially vulnerable to desertification. The nature and degree of this vulnerability depends on the interrelation between intrinsic features of the livelihood system and large-scale societal and demographic factors. In developing countries desertification is a predictable outcome in peasant dry farm systems when these are circumscribed within marginal lands, when supplementary income-generating activities are rendered obsolete, or when labour out-migration leads to a decline in field system maintenance. Due to its ability to invest capital in conservation measures, commercial dry farming seems in the short-term to have escaped the pressures characteristic of its peasant counterparts. Irrigation agriculture in both developed and developing nations suffers from problems of salinization, waterlogging, and potential

groundwater depletion. Vulnerability to this type of desertification will diminish for those schemes provided with adequate drainage and for individual users able to bear the burden of salinization control measures. However, vulnerability remains high for those unable to do so.

47. A balanced assessment of the relations among pastoralism, overgrazing and desertification awaits the collection of more comprehensive data. In the interim, it can be said that environmental degradation occurs when drought, the constriction of grazing lands due to political factors, the extension of cultivation, or sedentarization lead to a concentration of herds in specific locations. With few exceptions, pastoral nomads constitute socially and politically vulnerable groups within present day nation states. It is difficult, if not impossible, to isolate these external pressures from an assessment of pastoral land use and their threatened productive base.

48. Urban centres in the dry lands of developing countries are vulnerable to desertification, both as the result of intrinsic patterns, and as the result of rapid population growth. On the other hand, urban centres in the arid parts of the developed world appear to have transcended a dependence on immediate hinterland resources (except, in some cases, water) and seem able to prosper in spite of population growth and environmental limitations.

### III. THE SOCIAL CAUSES AND CONSEQUENCES OF DESERTIFICATION

49. The human experience of desertification is often obscured in the gross figures of animals lost, refugees and migrants created, ill-health experienced, trauma and stress endured, and inoculations given. Grinding and debilitating, the struggle for survival under harsh conditions is often a desperate, silent business. Frequently the sense of frustration engendered by cumulative events outside the individual's control colours the experience, while the promise of a bright alternative future in urban or technologically sophisticated modern systems often proves elusive. Considerable adaptive powers reside in the human systems exposed to desertification, and so successful are these coping devices that it frequently requires an extreme series of events to highlight the problem. Yet cause and consequence of desertification remain inextricably linked, if not always overtly observed. Their mutual interactions and interdependencies can be illustrated by a case example for a large-scale, integrated, irrigation-based livelihood system.

#### A. DESERTIFICATION AS A SYNERGISTIC PROCESS: DROUGHT, DESERTIFICATION AND SOCIETY IN MENDOZA

50. At time scales significant to people, desertification is a complex phenomenon in which one or more important processes of social change interact with natural fluctuations in climate and ecosystems. While the evidence is not conclusive, there is reason to suspect that desertification may be a synergistic process in which the existence of arid conditions breeds increasingly arid conditions, while the very remedial measures undertaken to reduce desertification's impact may lead to a long-term worsening of society's ability to cope with both natural and societal change. Moreover, not only does desertification have cumulative features, but also it is a selective hazard taking its heaviest toll on socio-economically marginal populations. Thus, one overwhelming feature of the desertification process in their lives is loss in their basis of sustenance and in their health and well-being.

51. The Mendoza oasis illustrates in its historical evolution and contemporary condition the complex, synergistic character of desertification. Located in the rain shadow of the eastern slopes of the Andes, Mendoza receives insufficient precipitation to support agricultural activities and instead must rely on irrigation water supplied by the district's exotic streams. It is, therefore, vulnerable to fluctuations in regional climate and weather, as well as variation in world market prices, inequities and complications in water rights and land tenure practices, price fluctuations due to overspecialization in grape monoculture, and urban encroachment on agricultural land. These forces have resulted in serious problems of waterlogging, salinization, and a differential diminution of social health and well-being.

52. Periodic shortfalls in precipitation, especially when they continue for successive years, while not in themselves responsible for desertification, cause severe problems for many oasis farmers (Hansis, 1976). Location at a distance from the main distribution canals increases vulnerability. This spatial disadvantage is reinforced by the legal structure of water rights which gives some properties priority rights to water (Morris, 1969). This insecurity in water availability leads to damaging misapplications of water in both

favoured and unfavoured sites. Salinization is frequently the result and is particularly acute for those farmers located at the base of a slope or downslope from heavy irrigation use. In such sites, soils often become waterlogged as the water applied to upslope areas accumulates in the groundwater table. The marginal farmer becomes doubly disadvantaged in such situations, because, located far from primary canals and thus exposed to crop loss due to moisture deficiencies, many are also threatened by the subterranean movement of excess water from their more fortunately located and endowed neighbours.

53. No factor is more important in contributing to desertification in Mendoza than is the land tenure system. Viticulture is the primary agricultural activity and large numbers of Mendoza farmers work under a sharecropping (*contratista*) system. While the owner of a property supplies the capital equipment and farm land, the *contratista* provides the labour. The contract generally runs for 8 years. During this time, the *contratista* must clear the land, plant it in vines, cultivate and harvest the crop, and pay 82 per cent of the yield as rent. At the end of the contract period the land reverts to the owner just as the vines reach maximum production and the sharecropper must look for employment elsewhere. Only if conditions have been unusually favourable will the *contratista*, who finds both profit and capital reduced during drought years, be able to save enough on this arrangement to purchase his own land.

54. The *contratista* system contributes to desertification in a number of ways. Because a *contratista* holds the land for only a short time, his ability and willingness to invest in capital improvements is minimal. Yet these capital improvements are often essential to reducing the risk of salinization. Improved distribution systems such as sprinklers or increased drainage are seldom found on *contratista* holdings. It is no accident that the most saline soils in the area are those in the oldest part of the oasis where the *contratista* system is most pervasive (Morris, 1969).

55. Moreover, soils in most of the Mendoza oasis are light and of loose structure. This exposes them easily to wind deflation and to rilling as a result of surface irrigation water flow. To some extent both wind and water erosion go hand in hand with human use of the agricultural potential of the oasis and are unavoidable. But much of their ill effect could be minimized if irrigation were conducted by more capital intensive sprinkler or drip irrigation techniques. For the *contratista* the capital to shift to such practices is nonexistent; anything that can be saved must be hoarded against the risk of future crop failures, depressed market prices or the possibility of acquiring one's own farm. The *contratista's* unwillingness to put capital into improvement of a short-term holding is matched by the landowner's reluctance to invest in upgrading land quality. For the landlord, the land primarily represents a long-term hedge against inflation (Morris, 1969) and, because the tenant and his labour are already present, there is little incentive to make *contratista* labour more productive, or the exploitation system more efficient, by investing in capital improvements. Indeed, the landowner can expect to make a profit even on desertified land, since the physical expansion of Mendoza city into nearby *contratista* districts makes the land valuable for non-agricultural purposes.

56. Specialization and integration into the global economy compounds the problems of the Mendoza oasis. Originally developed as a diversified agricultural oasis that produced its own food, while shipping alfalfa-fattened cattle over the mountains to Santiago, Mendozaan agriculture became increasingly specialized following the arrival of the railroad from Buenos Aires in 1884. Economic and environmental considerations favoured a concentration on wine and table grapes, and a flood of Italian and French immigrants

poured into the district. A prosperous global economy stimulated rapid expansion, but sudden drops in prices, especially during the thirties, visited economic hardship upon monocultural grape growers and increased the difficulties of the small farmers and *contratista* labourers of the oasis. Locked into a rigid land tenure system, they were unable to diversify production on their holdings. While some farmers replaced a portion of their vines with olives, the *viña baja* system of closely spaced vines made intercultivation difficult. Dependence on flow irrigation and an antiquated system of water allocation made water distribution too sporadic to permit the development of vegetable cultivation in the initially developed areas in the northern part of the oasis. Diversification into vegetables based on wells brought prosperity to the larger farms in the southern part of the oasis, but only served to increase the marginality and vulnerability of farmers and *contratista* located closer to the expanding urban zone of Mendoza.

57. The vulnerability of economically and socially marginal people to desertification in Mendoza mirrors the experience of other regions. However, unlike other examples of desertification causes and consequences cited in this section, population growth is not a prime factor in desertification in Mendoza. Rather, antiquated land tenure systems, differential access to technology, and exposure to market fluctuations appear to be prime casual factors. These, together with population dynamics, constitute the social causes of desertification.

## B. THE SOCIAL CAUSES OF DESERTIFICATION

### 1. Population Dynamics

58. The most important process of social change associated with desertification is demographic, the change in the numbers of people dependent for sustenance on the dry lands and in the numbers capable of providing such sustenance. In the conventional wisdom, this is described primarily as overpopulation, or as exceeding some implied carrying capacity of dry lands, at a fixed level of living and technology, beyond which desertification occurs.

59. The physical linkages between population numbers and desertification are well defined. Concentrations of people requiring firewood lead to the destruction of trees and shrubs, the destabilization of dunes, the degrading of vegetation and the exposure of soils to wind and water erosion. Overgrazing, arising from increases in herd size that originate in population increases or concentrations, plays a similar role, as does the cultivation of marginal lands to feed an increasing population. Finally, groundwater depletion is directly related to the amount of use, and waterlogging and salinization often accompany the decrease in fallow associated with more intensive demands on the subsistence base.

60. There are, however, many compensating mechanisms that can lead to population increase with little increase in ecosystem damage. Intensification of production, new livelihoods, migration, and technological change may all mitigate the inevitability of the physical processes. Overpopulation is an oversimplification that ignores the considerable variability in population density found in similar regions, the differences in population processes and trends world-wide, the ability of some societies and ecosystems to absorb considerable population increase with minimal ecosystem damage, and the ways in which a decline in productive population can also lead to desertification.

## (a) Population density

61. Aside from their climate and sparse vegetation, there is little that is shared by all the dry lands. Population densities and trends not only reflect the particular socio-economic setting of dry lands, but also the national setting in which they lie. This setting ranges from being a part of some of the world's richest countries to the poorest; from being closely integrated into the world economic system to being isolated and landlocked; from highly specialized, technological societies to near subsistence economies. It is not surprising that the carrying capacities of dry lands cannot be inferred from their current population densities.

62. Indeed, a comparison of estimates of such densities for the rural population of the dry lands as shown in Table 3 is evidence for the variety found in the deserts and desert margins of the world. Even when comparisons are limited to comparable zones and levels of economic development, the differences are highly significant. Densities range between less than one person to 10 people per square kilometre in arid zones, and between less than one person to 100 or more per square kilometre in the semi-arid zones. The greatest range is among the developing countries, with the poorest or least developed exhibiting densities similar to the industrialized nations. In both cases, these reflect the sparseness of settlement and isolation of arid areas.

63. The extraordinary range of population densities accommodated within broadly similar climatic zones should give pause to facile conclusions (Eckholm, 1976) regarding the carrying capacities of dry lands. Production systems have evolved in countries like India or Nigeria capable of sustaining much higher human densities than are found in much of the Sahelian-Sudanic zone or the Middle East. In the close-settled zone of Kano Province, northern Nigeria, population densities average 180 per square kilometre, while portions of semi-arid Rajasthan in India reach densities of 150-200 per square kilometre. Despite such striking examples of success in supporting large populations in areas that elsewhere are lightly populated and/or prone to desertification, there are few comparative studies of the indigenous human ecology of homoclimatic areas. Such studies constitute a first step in explaining these apparent variations. Until this is done, inferences as to inevitable desertification by population growth seem unwarranted.

TABLE 3. *Dryland rural population densities by number of countries and economic development*

Zone and economic development		Number of countries with zonal density/km <sup>2</sup>					
		< 1	1-10	10-25	26-50	51-100	> 100
Extremely arid:	<i>N</i>						
Poorest nations	(7)	3	3	1	—	—	—
Other developing	(12)	5	6	—	1	—	—
Industrial	(2)	2	—	—	—	—	—
Arid:							
Poorest nations	(13)	5	7	1	—	—	—
Other developing	(30)	3	15	8	3	—	1
Industrial	(5)	2	2	—	1	—	—
Semi-arid							
Poorest nations	(10)	1	5	4	—	—	—
Other developing	(31)	2	12	5	6	5	1
Industrial	(5)	2	3	—	—	—	—

64. At the same time, the broad range of population densities conceal a major emergent problem of underpopulation, in that a decline in agriculturally active people may imperil the continuity of an indigenous productive system or the viability of a settlement. In many developing countries, indigenous systems are declining locally in productivity as a result of the temporary or permanent migration of the most active members of the work force. Such migration may be in response to the attractions of higher wage returns (as of Yemenis to Saudi Arabia; Dow, 1975; Shamekh, 1975), or they may arise from the desperate condition of drought (e.g., Faulkingham, 1976; Brooks, 1976) or declining productivity due to desertification, reduction in fallow and soil nutrients, and overgrazing. The initial impact of the out-movement of active males may well be favourable, when through their remittances new resources are brought to an impoverished area. But there are increasing signs that a critical point is reached in which the resource base itself becomes imperilled by the lack of workers needed for the maintenance and operation of labour-intensive cropping systems (e.g. Nolan, 1975). The literature is ambiguous and contradictory when attempts are made to assess whether the migrant and his larger social system is better or worse for the change, and strong opinions are held on either side. The main loss in such situations is the decrease in production from the local resource base that often accompanies such migration, but whether these production systems could survive in any case in the face of changing economic relationships is unclear. Certainly little attention is devoted to their problems and potentials. This neglect is especially tragic if one assumes (as seems likely) that population growth will continue in most semi-arid regions in the decades ahead; under such conditions of depopulation many indigenous production systems will no longer be able to make their accustomed contribution. For those countries with only limited productive opportunities, losses of this type are particularly serious.

65. In the industrialized countries, agricultural production remains high in the face of continued out-migration and decreases in the number of agriculturally active persons. What are imperilled in these situations are the urban-based livelihoods in the commercial and service centres of the lowest level of settlement. In Australia and North America, for example, the smaller settlements of the dry lands face a continuous and unfavourable struggle for viability and survival (Heathcote and Williams, 1976).

#### (b) Population trends

66. Data with which to analyse the demographic characteristics of dryland populations are scanty, for only 20 of 58 dryland countries have published a census in the last decade. Moreover, the data that do exist are often of questionable accuracy. Still, some figures and trends, however tentative, allow us to make an interim assessment. From among the 58 countries with considerable dry lands, five patterns of demographic change or scenarios for the future emerge. These types are associated with level of economic development, sparseness of rural population and their isolation, and degree of control exercised in settlement policy. Table 4 describes the component rates for each pattern.

67. A significant number of the world's dryland population live in isolated countries that have experienced only a minimum of socio-economic change and integration. The urban and rural population of dry Chad illustrates many of the population trends characteristic of this situation. The traditionally high birth rates remain greater than 40 per thousand, with the death rates between 25 and 30 per thousand (Reyna and



TABLE 4. *Population trends in dryland countries*

Pattern (N = 58)	Trend component				
	Births	Deaths	Immigration	Out-migration	Overall growth
I. Isolated, least developed nations (22)					
Urban	High	Moderate	Moderate	Negligible	Moderate
Rural	High	High	Negligible	Moderate	Low
II. Developing nations, uncontrolled settlement (28)					
Urban	High	Low	High	Negligible	High
Rural	High	Moderate	Negligible	High	Low
III. Developing nations, controlled settlement (3)					
Urban	Moderate	Low	Low	Negligible	Moderate
Rural	High	Moderate	Negligible	Low	Moderate
IV. Industrialized nations, uncontrolled settlement (4)					
Urban	Low	Low	High	Negligible	High
Rural	Low	Low	Negligible	Moderate	Negligible
V. Industrialized nations, controlled settlement (1)					
Urban	High	Low	Moderate	Negligible	High
Rural	High	Low	Negligible	Moderate	Moderate

Bouquet, 1975). Migration from the rural dry areas, an influential component of many dryland growth trends, is comparatively moderate. Under normal conditions, most of this movement is of a seasonal nature and limited to adult males who migrate to urban centres either within the dry area or in the humid regions where economic opportunities may be greater.

68. Yet even in this state of development, rural out-migration to the capital and other key cities is occurring. In the capital city of Chad, N'Djamena (population 100,000) at the fringes of the semi-arid area, annual population increase due to immigration was found to be around 4–5 per cent in addition to its 1.5 per cent natural growth rate. However, given the recent civil disturbances in the north of the country it is uncertain how large a percentage of this increase originated from dryland populations. Under drought conditions out-migration greatly accelerates and temporary migration across international borders is also significant.

69. In countries such as Chad, present trends indicate moderate urban growth in small cities and low rural increase. The critical component in this prognosis is the death rate; this can be anticipated to fall in the next two decades with improved health care delivery to children and reduction in infant mortality patterns (Caldwell, 1975).

70. In the midst of development, the dryland population growth trends of Mexico illustrate many of the demographic characteristics of people undergoing rapid

socio-economic transformation. Death rates have been lowered, especially in the urban centres where they are just 8 per thousand, while birth rates remain high, 47 per thousand (CONAZA, n.d.). The rural population, experiencing relative environmental and economic impoverishment, is migrating in accelerating numbers to urban centres both humid and dry. The result is that dryland cities have been growing at an annual rate of 6.0 per cent for the past 20 years with 20 to 30 per cent of the inhabitants coming from the countryside. These cities now account for half of the dryland population (MacGregor and Valverde, 1975). The flight from rural areas to the cities has also had the effect of dampening the rural growth rate considerably to between 0.7 per cent and 1.3 per cent in some areas. The lowered rural growth rate has the effect of reducing total dryland population growth rates below the national average (2.5 per cent compared to 3.2 per cent), although with the urban component it is still high.

71. Although many dryland developing countries have a similar pattern, several exceptions exist. India, with many of the same component trends as Mexico, has not experienced the same degree of out-migration from its arid areas. This is probably due to the absence of strong economic alternatives elsewhere and the success of rural irrigation projects such as the Rajasthan canal project (Singh, Singh, and Singh, 1971). The net effect has been an extremely rapid increase in rural densities. For example, in the Rajasthan arid area, densities have doubled over the past four decades and the growth rate of the arid areas is slightly higher than that of the national average (Fig. 4). While many farmers appear to believe that conditions are worse now than in the past, most observers have concluded that desertification has not increased commensurate with the areas's higher population densities.

72. Very little precise data is available for many dryland populations and the Peoples Republic of China is no exception (e.g. Chen, 1973). Nevertheless, it is probably the leading example of controlled settlement in the developing world. A successful attempt to regulate the movement of people, particularly the rural to urban migration pattern, by minimizing regional economic disparities produces a population trend that is qualitatively different from other developing countries (Tien, 1973). This policy was first introduced in 1958 and is characteristic of most countries with planned settlement policies. The primary effect of these policies is to reduce rural out-migration rather than to reverse the process.

73. Australia and other industrialized countries differ strikingly in their demographic trends. Birth and death rates are low (20 and 9 per thousand respectively) and the

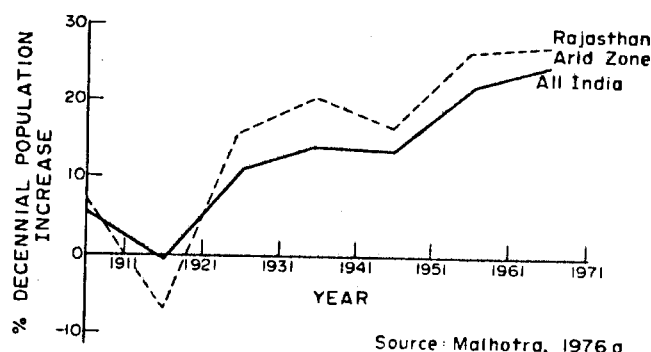


Fig. 4. Decennial increase in population in Rajasthan arid area and in all India

natural growth rate is only 1.1 per cent (Australia, Commonwealth Bureau of Census and Statistics, 1973). Dryland population increase and decrease is strongly affected by migration. There is intense migration to the larger urban centres from both the dry and humid rural areas. The decreasing influence of communal ties, the expansion of communication networks, and the ease of mobility characteristic of an industrialized nation, make the social and economic attraction of the cities more powerful than in any of the other four demographic groups. This movement is encouraged by an economic shift from agriculture to extractive industries, light manufacturing, and tertiary activities. In many rural areas, this combination of low birth rates and out-migration results in a negligible, even negative, rural growth rate. Because of mechanized farming, the rural population of Australia has decreased in both dry and wet areas not just as a percentage of the total, but also in absolute numbers.

74. In the Soviet Union, an industrialized nation with controlled settlement, the demographic trends of the dry lands reflect the government's policy of developing the economic and population base of these regions. Here urban growth has been averaging over 5 per cent and the rural growth rate is over 3 per cent per year (Harris, 1971). It is anticipated that with industrial development, the dry land's growth rates will decrease and conform more to the national norm. At this scale, the 1970 Census indicates that low birth rates and regulated migration have effectively reduced urban growth to just over 3 per cent per year while rural numbers remain constant.

75. In summary, population trends indicate that most of the world's dry lands people are rapidly expanding their numbers, but at rates lower than national averages with major exceptions being India, Pakistan, the USSR, and the United States. This less rapid growth is a product of the lower growth-rate of dryland populations who have yet to experience rapid reductions in death rates and of the out-migration of rural people to cities which are often outside the arid zone. In many countries this process is only beginning, and, to the extent that population pressure is related to desertification, the peaks are yet to be experienced. In the wealthiest nations, lower rural population growth rates ameliorate the worst effects of the process. But rapid growth of urban centres and the money economy can also encourage rural depopulation and the loss of labour required to maintain traditional livelihoods in developing countries and the viability of smaller settlements in industrialized countries. These trends are often moderated in both industrialized and developing nations when planned settlement is employed. Overall, in terms of the relationship of demographic change to desertification, the critical components are the expected future reduction in death rates in the isolated, least-developed countries, and the degree to which national governments are able and willing to regulate rural to urban migration everywhere else.

## 2. Change in Social and Political Structures

76. The societal forces that interact with the physical environment to produce desertification are themselves constantly changing. Just as the dynamics of human populations, in the ebb and flow of their demographic structure and spatial location, are both cause and consequence of desertification, so too are changes in global social, political and economic structures important variables. Because these cause and effect relationships are often indirect, feedback in the system is complex and causes are both multiple and several stages removed from consequences. This makes it difficult to distinguish between

general processes of change and desertification. Yet desertification changes at a local scale can often be traced back to forces and processes set in motion in distant places, while the problems of desertification (and, in more dramatic fashion, drought) in semi-arid regions set in motion events whose ramifications ultimately impinge upon the resources and consciences of the denizens of more favoured climes.

77. For much of the dry world it is a shift from relatively closed and isolated to increasingly open, interlocked, and interdependent systems that has significant influence on desertification causes and serious impact on the well-being of communities exposed to desertification. In particular, changes in the social order, varying rates of technological growth, and fluctuations in the authority and wisdom of central governments all intersect, at differing scales, with the livelihood practices of dryland peoples, to produce or compound the problem of desertification. Some ramifications of these processes, and their impact on the health and well-being of individuals and groups, are outlined in these and subsequent sections.

(a) Integration, specialization and constriction of livelihood systems

78. Dry lands were the locus of some of the great civilizations of antiquity. As such, they became centres of regional and even continental integration of power, trade, and production. Periods of power and prosperity have fluctuated with periods of poverty and isolation. Typical of these fluctuations are the  $2\frac{1}{2}$  cycles of population growth and decline over 4000 years that have been documented for the Diyala floodplain of Iraq (Adams, 1965; see Fig. 5). The causes of these great fluctuations are complex, but they involve dramatic changes in the social order occurring at a time when an over-extended irrigation system was struggling with waterlogging, siltation, and salinization.

79. We live in a new interdependent world where these historical centres have been relegated to the periphery. The links of this interdependence were forged by the sixteenth-century European expansion into Africa, Asia, and the New World and reconstituted in a somewhat different form by the nineteenth-century imperial powers. This undertaking destroyed or dismantled many non-Western civilizations, decimated or

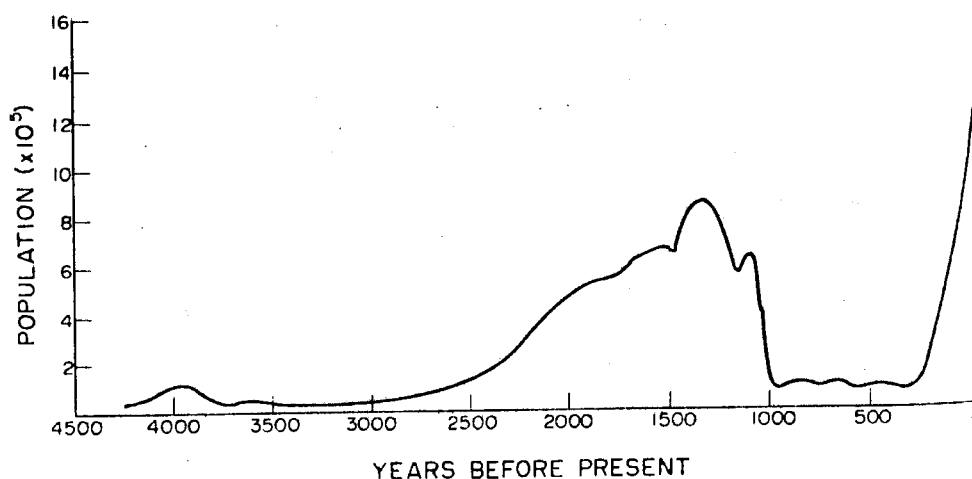


Fig. 5. Population fluctuations in the Diyala floodplain

enslaved populations, and, in Saharan Africa, reoriented an entire system of trans-continental trade to serve new North American and European ends. The wealth generated in the process of transforming old centres into new peripheries flowed to the growing European core, fuelling an industrial revolution which, in its turn, created new integrative bonds.

80. This interdependence is still with us, albeit clothed in a twentieth-century, post-colonial garb. The basic trend is toward wider coordination into a world system of production and exchange. Isolated and self-sufficient systems are increasingly becoming the exception rather than the rule. Systems tied to a world market with specialized functions are the new norm.

81. These world-scale processes also operate within nations as dryland regions increasingly become peripheral to more humid centres of power and production. Nonetheless, they continue to provide needed raw materials and foodstuffs. Thus, milk moves nearly 500 kilometres from the Rajasthan desert to the markets of Delhi, and beef moves 7500 kilometres from the central desert of Australia to the markets of Tokyo.

82. This economic and political integration and specialization is further complicated by the selective constriction and isolation of certain livelihood systems. For example, the often artificial borders of the now independent, former colonial states place serious new obstacles in the path of the long seasonal migrations characteristic of animal-based livelihoods at the same time that traditional grazing lands have been occupied by agriculturalists.

83. The implications of this historical evolution for an understanding of desertification are manifold. As traditional societies inhabiting what until recently had been peripheral dry lands undergo a process of change, and old livelihood strategies become unviable options, both the natural and the cultural components of their ecosystem deteriorate. O'Keefe (1975) and Wisner (1976) illustrate the unfolding of this process at the village level in Kenya. When additional stresses, such as drought, are placed upon the system, it becomes hard for it to recover on the basis of purely endogenous resources. Yet, due to its still peripheral status, outside resources do not readily flow in upon demand, thus further hampering recovery. Growing integration into a world system has meant relief in some cases, and, over the long run, perhaps new opportunity. However, to date, relief has generally been limited to palliative efforts and we have yet to see the new interdependence of the world translate itself into positive development for these threatened arid ecosystems.

84. Similar implications hold even in wealthy countries. The arid lands of the wealthy countries play little or no subsistence role for their own peoples, only serving distant export markets through capital-intensive productive systems. The problems are not nearly as dramatic except for some marginal peoples of industrialized centres, e.g., Australian aborigines and native North Americans. Nevertheless, because ecosystem management becomes subject to the vagaries of distant markets, economic demands may be out of step with climatic potential and the basic system inevitably leads to the loss of smaller communities and populations.

(b) The invasion of new and retreat of old technology

85. There is no such thing as a non-technological society. All peoples possess knowledge and equipment enabling them to produce the means of their subsistence. Some societies, however, possess a powerful and modern technology while others possess

technology that has not changed substantially since the neolithic. This unequal development of different societies' productive forces has meant that there has been a retreat of the indigenous technologies and a growing hegemony of Western science and technology. This process unfolds along two characteristic paths. The first occurs when indigenous technologies atrophy, land use changes, and a technological vacuum is created. Entire spheres of productive activity then disappear, resulting in a loss to productive use of significant portions of the ecosystem. In arid and semi-arid lands this may entail desertification. For example, once ancient water-collecting systems are first neglected and then abandoned, the investment in labour and capital required to bring them back into production is too great and they may disappear forever.

86. The second path along which indigenous systems retreat involves their direct competition with modern technology. In these instances modern productive enterprises compete successfully with traditional systems, enabling the former to gain control of scarce resources: water, land, and labour. This, in turn, may lead to the wholesale abandonment of traditional resource-use techniques. In these areas where the competition is not with agriculture but with urban spread, the trend has accelerated. Iraq, for example, has lost almost half of her date palms to urban-based livelihood systems in the past 15 years (Fahmi, 1976).

87. The transition from indigenous to modern technologies has not always brought about the desired levels of social well-being that an increase in productivity might suggest. The substitution of modern for indigenous technology, linked as it is to rates of structurally unequal development, has proven an inadequate vehicle for integrated social change. Punjabi farmers were among the major beneficiaries of the Rajasthan irrigation canal, but the nomadic inhabitants became worse off with a shrinking grazing area (Malhotra, *et al.*, 1976). Moreover, the new technology is often available only selectively to members of the traditional community. Those owning land, possessing capital, or having access to education and information are most likely to be in a position to benefit from the new introductions. Not only do the resulting introductions often increase existing social disparities, but also they tend to eliminate labour-intensive coping mechanisms found in more traditional technology and supported by indigenous value systems. The consequence is often increased pressure on the most marginal resources, partial – and frequently destructive – integration of technology into local productive systems, and the breakdown of existing, often supportive, social arrangements.

88. But something more than well-being is lost in this unequal contest. The natural evolution of indigenous technologies is truncated by the importation of exotic techniques bearing no organic relation to people's ecological setting or to their culture history. What often confronts them is the invasion of modern technology, rather than its rational integration into the productive fabric of the society. Since industrial technology, and the management practices associated with it, are generally outside the experience of practitioners of the traditional system, or run counter to their objectives, values, and customary wisdom, adoption of such innovations is often retarded or is rejected outright. Careful attention to the fit between the traditional and the modern, and to the identification of appropriate technologies, is an essential prerequisite in the struggle against desertification.

89. By truncating the evolution of indigenous technologies, the world also loses much accumulated folk wisdom. These indigenous technologies are not simply anthropological anachronisms, but contain valid, time-tested principles built on detailed local knowledge.

With the new opportunities and threats that arise from a wider world integration, specialization and constriction, they need to be given opportunity to evolve and change. Unfortunately, they tend to disappear. For example, there is probably no better way to extract the diffuse and marginal resources of arid lands than pastoral migration. But most efforts at change seek to sedentarize pastoralists and to limit them to fixed ranch locations, instead of seeking to modernize pastoralism (using radio, trucks, etc.) in order to capitalize on its mobility. The destruction rather than the evolution of pastoralism can lead either to a new loss of productivity or to overgrazing of a more constricted area, both of which are forms of desertification.

(c) Political structures and desertification

90. Ironically, central governments are responsible both for resisting desertification and, generally inadvertently, for stimulating its spread. This ambiguous situation can be illustrated by several examples, with irrigation civilizations being a particularly poignant case. While it is unlikely that an integrated centralized state was an essential causal mechanism in bringing complex irrigation systems into existence as is suggested by some (Wittfogel, 1957), it is certain that, once established, co-operative activities such as canal cleaning and maintenance require considerable centralized direction if an integrated system is to be maintained.

91. The Kara-Kum canal in Soviet Central Asia is an example of the way central governments can organize resources and overcome scale problems to bring water to areas that once were seasonal pastures (Petrov, 1976). However, historical experience shows that the system created is utterly dependent for success upon the continuity of governmental resources, attention, and authority. Any decline in authority is quickly followed by problems of canal maintenance, difficulties in water distribution, and a diminished ability to support existing populations (Adams, 1965; Fernea, 1970).

92. Run-off farmers in semi-arid areas are also vulnerable to changes in governmental effectiveness. Ecologically astute systems (Kassas, 1972; Evenari *et al.*, 1971) that make use of extremely limited and sporadic rainfall, they depend on the security provided by central governments to resist the potential depredations of their nomadic neighbours. When the government's fortunes decline, these marginal agricultural regions slip into eclipse. Such episodic collapses have resulted in the desertification of large tracts of semi-arid and arid lands, as evidenced by the fluctuating fortunes of the Diyala floodplain (Fig. 5).

93. But just as central governments can increase productivity by providing support to irrigation and run-off systems, so too can their demands for increased productivity, combined with technological difficulties, contribute to desertification. Salinization appeared by 4000 B.P. in the Tigris and Euphrates floodplain as a result of over irrigation and poor drainage (Jacobsen and Adams, 1958), while decreases in the fallow cycle may well have been the mechanism that instituted desertification in much of Mesopotamia (Gibson, 1974). Similarly, government efforts to promote agricultural development in desert oases have often dramatically increased both salinization and sand-dune encroachment (Meckelein, 1976). In the pastoral sphere, governments have done much to develop water resources. While intended for use by the pastoral community, these well and surface flow collections facilities have frequently become growth points for a settled agro-pastoral population. The resulting intensification of grazing pressures frequently

contributes to wind and water-borne soil erosion, to impoverishment of vegetation resources, to increasing administrative and legal difficulties for mobile pastoralists (Ahmed, 1973), and to the spread of desertification. Indeed, there is reason to fear that an inevitable corollary of development may be the enhancement of desertification, unless fundamental changes in priorities occur, for a recent simulation of the effects of the aid programmes proposed for recovery in development of the drought-afflicted Sahelian region showed that the result to be expected is rapid and complete desertification of pastoral areas (Picardi and Seifert, 1976).

94. In summary, central government policy and practice are intimately associated with desertification. Its record over both long and short time scales is a chequered one and, like so many other facets of exploitation of the humanized earth, both good and bad consequences have resulted. In many cases the security and central direction provided by governments has been essential to the use of dry lands. But the very conditions that encourage exploitation of the dry margins may also promote the spread and intensification of desertification, thus contributing to the synergistic character of the problem. No special aura of success and rationality is attached to central bureaucratic structures and they should be employed only with caution and with a healthy respect for their limitations as well as their potentials.

### C. THE SOCIAL CONSEQUENCES OF DESERTIFICATION

95. The consequences of desertification are manifold and extend from decreases in the productivity of the resource base to the emotional and physical traumas visited upon individuals and societies. However, discussion here is limited to those that effect, or are manifest in, social practices and structures. Two levels of consequences are identified: those that are highlighted in the direct experience of individuals and small groups, and those that have a far-reaching effect on large numbers of people. Within this latter category two particular consequences, migration and changes in health and well-being, seem to be most important.

#### 1. The Human Experience of Desertification

96. An understanding of the full implications of desertification hinges, in part, on the ability to view the process at an immediate human scale. The family household or community occupying an area undergoing desertification may have to respond to short or long-term ecosystem change, to the movement and growth (or depletion) of animal and human populations, to changing relations in the total socio-economic system, and to the obsolescence of old and invasion of new technologies. The nature of this response will increase or decrease the family or community members' vulnerability to the desertification process. In all cases the family or community response is linked to a series of desertification-induced pressures which constitute the immediate consequences of desertification. These consequences are felt in their most acute forms by those marginal peoples least able to bear them.

97. Drawing upon data contained in the Profiles of Change (available in the supplementary materials) this section reviews the consequences of desertification as experienced by selected vulnerable peoples. Because the dynamics of productivity loss are



analysed by Warren and Maizels (1976), the aim of this brief section is to highlight the effects of desertification upon human livelihood and sustenance.

98. The consequences of desertification upon agriculture-based populations range from loss of their resource-base productivity to imperilled health and forced migration. The short case studies tell of:

- . . . peasant farmers in Central Mexico whose deteriorated terraces retain less field moisture. This leads to lower yields and often to crop failure in three out of five years;
- . . . sharecroppers in north-east Brazil whose holdings are affected by soil erosion and declining fertility; when their households' ability to produce enough food to cover basic needs and to survive drought is threatened, impoverished farmers stream into urban areas;
- . . . peasants in Rajasthan who must contend with overgrazed pastures, deforestation, soil erosion, and salinization of irrigated lands; growing numbers force cultivation of marginal lands, thus increasing vulnerability to drought as well as contributing to the degradation of their resource base;
- . . . Argentinian sharecroppers and smallholders whose lands are being waterlogged and salinized and who cannot afford the capital investment necessary to reclaim them; faced with declining yields, as well as inflation and uncertain market conditions, these skilled farmers often must give up their holdings and migrate to low-paying jobs in the cities;
- . . . commune dwellers in the People's Republic of China who must mobilize large quantities of labour in order to combat dune encroachment. In one county, peasants established a tree belt 5 kilometres long and  $\frac{1}{2}$  kilometre wide in order to hold down drifting sands; they constructed sand dams totaling 35 kilometres in length in order to expand their fields; and they drilled thousands of wells in order to combat drought;
- . . . Cape Verdean peasants who underwent famines due to a deteriorating resource base and social inequities and who now, following independence, face the task of rebuilding a degraded resource base on the strength of mass mobilization and self-rule.

99. Desertification also entails pressures upon the livelihood patterns of animal-based peoples. Often these pressures threaten an entire way of life and compel sedentarization. Thus:

- . . . Fulani nomads find it increasingly difficult to reconstitute their herds after drought and 25 per cent of those who arrived at one refugee centre during the last Sahelian drought are now considering non-pastoral work because they lack sufficient livestock to resume pastoralism;
- . . . Iranian settled nomads find their agricultural resource base inadequate to sustain their needs and health as evidenced by low standards of living and a high infant mortality rate;

. . . Pakistani fishing peoples are faced with the prospect of a lake drying up due to drought and to upstream irrigation water withdrawals which deprive them of their livelihood and contaminate their water supplies.

100. By drawing upon outside resources, urban-based populations can sometimes buffer the immediate effects of desertification. Nevertheless, rapidly growing urban concentrations often place strains on their immediate hinterlands. This can occur in both large- and small-scale concentrations. For example:

- . . . newly settled *ujamaa* villages in Tanzania must contend with devegetation and diminishing soil fertility in the environs of their settlement; this implies that scarce resources will have to be allocated for afforestation projects and for fertilizer;
- . . . so far, Tucson, USA, has been able to provide for its water needs from ground water supplies. However, if demand for residential and industrial water keeps increasing, the city may be faced with water resource depletion and the need to divert water away from its highly specialized commercial agriculture.

101. The experience of desertification is a widespread one in all dryland societies. In industrialized and urban livelihoods the resources available to combat desertification are greater and the possibilities for transcending its consequences are more numerous. For families and livelihoods on the margins of the modern world, or for those isolated by tradition, social inequalities, ignorance, and indifference from access to the resources and organization required to resist desertification, the experience of productivity loss is often bleak and barren. For them diminished health, social stress, stagnation, migration, and the abandonment of time-honoured ways of life constitute the human experience of desertification and mirror its social consequences.

## 2. The Social Consequences of Desertification

102. The experience of desertification at an individual, human scale is often a subtle process that accumulates slowly and is often difficult to distinguish from other changes that are taking place. This is especially true when large groups are considered, and the difficulty is compounded by both lack of data and insufficient focus in previous work on the desertification process itself. Nonetheless, both in terms of causing movements of people and changes in health and well-being, desertification has a significant, if at times ambiguous, impact on the structure, sustenance, and stability of social systems.

### (a) Migration as a response to desertification

103. Mobility within local rural areas and out-migration to settle in urban areas are adjustments to environmental and political conditions in dry lands that have existed for centuries in both nomadic and settled livelihoods (Lee and DeVore, 1968; Mitchell, 1969; McGee, 1973; Mangin, 1970; Redfield, 1956; and Wolf, 1966). In this light, migration in response to the long-term decrease in productivity associated with desertification can be seen as an adjustment that is a continuous extension and expansion of an established adaptation.

104. Except for the sudden impulse given to migration by prolonged drought, migrants

from desertifying districts pass unnoticed in the larger flow of population from rural to urban centres. Initially, migration represents a short-term adjustment to a temporally limited period of adverse conditions. Migrants in this situation exploit urban resources only during crisis (Graves and Graves, 1974) and envision returning to their village setting once environmental conditions improve. Only when drought continues for several consecutive years, often exposing underlying desertification or raising doubts in refugees' minds about future resource base productivity, do migrants plan to remain in, or to seek alternative livelihood options. This apparently accounts for the large number of those interviewed who indicated unwillingness to return to their original Sahelian habitats even if some governmental assistance were provided (Laya, 1975).

105. Longer-term adaptations generally involve the establishment of more or less permanent ties between two economic systems, one rural and one urban, and the periodic movement of labour between them. The initial result of this linkage is to improve the total productivity of the rural system in question. Nolan (1975) indicates that the situation of the Bassari community in eastern Senegal was improved by monetary remissions from migrants engaged in urban employment. While these cash returns seldom are very large (Campbell, 1976b; Nolan, 1975), they are essential to largely subsistence communities if taxes are to be paid and consumer goods purchased. As long as the labour consumed by urban employment is small and the migrants return to provide needed communal labour during crucial periods of the agricultural year, the results are an improvement or stabilization of existing living standards. But when labour migration begins to compete with the labour required to keep the traditional agricultural system functioning, conditions rapidly worsen in the traditional sector. At the same time, for those migrants who choose to remain in urban employment for extended periods, the change frequently involves an improvement in economic potential and living standard. The resulting network of kin living in rural and urban areas serves as a communications network for the flow of people, information, and materials, and provides a ready-made point of contact in the urban milieu for those individuals who wish to follow their kinsmen into an alternative life style.

106. This network is particularly important when desertification pressures become intense, since a supportive network of relationships exists to assist a more rapid and large-scale movement away from afflicted districts. Yet the very success of urban migrants often undercuts the viability of the traditional sector. As soon as too many migrants stay away too frequently for too long, the productivity of the rural resource base decreases as the labour available is no longer sufficient to maintain yields. Migrants in this situation become both cause and consequence of desertification. An example, among many, is provided by the Otomi Indians of central Mexico who, in order to seek wage employment outside their communities, are forced to neglect their terraced fields. The unmaintained terraces erode and fail to provide the moisture-retaining capacity needed to produce dependable yields under erratic rainfall conditions. In good years, the average family holding yields a 6-month supply of maize. In bad years it yields nothing. Farmers are often even unable to harvest enough fodder to keep their livestock through the winter dry season. This, in turn, places a heavier burden on the already overgrazed communal pasture land. Consequently, precious animals weaken and die during the winter months, further threatening the family's survival-hedge. The old pattern of life appears inadequate to maintain Otomi households, and thus accelerates the out-migration of much needed labour power (Johnson Haring, 1976b).

107. The search for economic improvement in urban areas thus involves more and more individuals. As social bonds between migrant and home base weaken, those left behind are increasingly marginalized and a debilitating retrogressive spiral can be instituted. What initially appeared to be a stable dual economy becomes a prescription for decline at the margins. Physical and social desertification march hand in hand, often spurred on by drought, and increased migration often represents the individual's and the group's only option. The motive underlying this spontaneous migration is economic; both the image and the reality of improved well-being attract the migrant. It seems likely that resettlement and development schemes designed to combat desertification will be most attractive to potential migrants and will have the best prospect for success if they place their highest priority on the economic benefits that will accrue to participants. Similarly, the flow of migrants can be channelled most judiciously and their integration into new livelihoods can be accomplished with least stress if migrants are provided with needed skills via relevant educational programmes.

(b) The health and well-being of individuals and groups

108. In regions undergoing desertification, many sedentary farmers, nomadic pastoralists, and recent urban migrants are caught in a web of inadequate diet, disease, poor sanitation and inadequate health care services. They suffer physical debilitation, demoralization, and emotional stress as a result. This traumatized physical and emotional state hampers the adaptive abilities needed for successful change. Yet in experiencing these calamities, desertification-afflicted communities and individuals are not appreciably different than other social groups involved in rapid and traumatic change. Similar problems emerge and there is little that is distinctively and uniquely related to desertification. Only when desertification, drought, and disease coincide are the chronic problems of desertification-prone populations different in scale from those experiencing more general pressures associated with development and culture change.

109. If there is one health aspect of desertification that is popularly recognized as a serious problem, it is malnutrition and, ultimately, death by starvation. Certainly the loss of productivity characteristic of desertification leads logically to the conclusion that death by starvation is inevitable for a population without alternative life-support options. However, the evidence to support this belief is lacking, and most existing information is related to drought-induced famine rather than desertification. Malnutrition was found among migrants to refugee camps during the Sahelian drought, but levels were not appreciably greater than those of individuals who did not move to camps (Seaman, *et al.*, 1973), perhaps because famine is essentially over before action can be taken to cope with it (Gebre-Medhin, 1974). Nomads exhibited higher levels of malnutrition than migrants from sedentary populations (Greene, 1975; Sebai, 1969; Omolalu, 1976), but this differential is as easily correlated with distance from relief outlets as to generally lower nutritional levels or to greater ecological vulnerability.

110. Yet crop failure, famine, and disease are related, as are the intensifying features of drought years in desertifying regions. During the recent drought in the Sahel, Hausa cultivators may have suffered up to a 70 per cent loss of their normal harvest. Hard pressed farmers resorted to cash cropping in limited well-watered areas, wage-labour, out-migration, and foraging in order to feed their families. In spite of this, a food crisis ensued. In part, this was due to the failure of cash crops on which peasants depended to

provide capital for essential purchases. Other factors may have included the calorie and protein deficiencies that frequently develop when migrants move to areas where traditional foods are not available and new substitutes are often nutritionally inadequate. In addition, as new technologies are introduced, folk use of important resources such as famine foods frequently diminishes; in desertifying settings such foods may no longer survive to nourish a drought-affected population.

111. Despite these nutritional problems, drought-related deaths in the Sahel were less numerous than originally feared precisely because the region's integration into the global economic and political system permitted a rather rapid and effective response. Where mortality did increase, it was disease related and affected the young, aged, infirm, and pregnant as opposed to the entire population. This pattern of drought, famine, and disease in areas exposed to desertification is closely paralleled among peasant cultivators in semi-arid Kenya who must operate within a constricted resource base. Their surplus product in good rainfall years is insufficient to carry them through the bad; this places the vulnerable members of the population, the very young and the old, in jeopardy from malnutrition and gastrointestinal diseases (Wisner, 1976). But it is important to emphasize that desertification's impact on nutrition is indirect, and that no evidence presently exists correlating malnutrition and desertification.

112. Analogous difficulties obscure the relationship between desertification and infectious diseases. Only trachoma exhibits an apparent distributional relationship between aridity and incidence of the disease (Tarizzo, 1976), but this is more apparent than real. Its control has been achieved outside the dry world and only isolation and insufficient resources prevent trachoma's demise within it. Other diseases, such as leishmaniasis, schistosomiasis, and trypanomiasis, are associated with attempts to make dry environments more productive (Ormerod, 1976), but few would forego these projects to avoid disease. Rather, they would try to minimize the disease potential. Dust exacerbated respiratory diseases are likely to be somewhat more frequent where desertification is increasing, but these do not seem to be significant problems. Sanitary problems associated with sedentarization and migration to urban concentrations are hardly unique to the desertification process. There appears to be no diseases or related health problems so closely related to desertification that they qualify as fellow travellers which require singling out for specific attention. This conclusion does not in any way eliminate the need and responsibility to focus international attention on these and other health problems related to development and human well-being. But it does suggest that there are few health problems uniquely linked to desertification and that the resources available to combat desertification *per se* should be targeted in other areas.

113. Certain longer term changes affecting the health and well-being of social groups should also be noted. Loss of a privileged social position placed most pastoral groups in a powerless position *vis-à-vis* governmental authority in the pre-drought era and increased the sense of helplessness engendered when environmental adversity arrived to compound political and economic constraints. Many farmers most seriously affected by the drought were also economically marginal, many having migrated into agriculturally vulnerable areas when their own agricultural land was pre-empted for commercial production. Use of increasingly marginal resources invariably involved greater distance between and less social interaction with compatriots. As resource productivity decreased, social bonds that once were crucial to individual and group viability were shattered because neither the resources nor the coincidence in time and space were sufficient to maintain them. Thus social

networks that normally supported individuals were already in decline in many areas before the Sahelian drought struck and coping mechanisms were in an atrophied state. Moreover, vulnerability increased in direct proportion to the breakdown in social networks, the decrease in livelihood interdependence, and the increasing tendency to concentrate on specialized production. All these factors contributed to a lack of social, economic, and political well-being which was preset for disaster when drought exposed basic desertification pressures.

114. Yet despite the multitudinous stresses brought to bear on individuals and groups, basic adaptability remained. Many nomads stressed in this way showed considerable willingness to engage directly in agricultural development projects such as Tin Aicha in Mali (Smith, 1976). Farmers were able to engage in wage labour migration without abandoning their commitment to the traditional village scene (Faulkingham, 1976). Moreover, nomadic groups have shown considerable ability to bring their production activities more closely into line with modern organizational concepts. Mongolia's experience indicates that stress can be moderated in a development programme if attention is paid to traditional patterns (Aubin, 1967; Humphreys, 1976), while traditional *hima* systems of grazing resource control have been found suitable for development in a co-operative context (Draz, 1974). The record, therefore, is ambiguous. Severe stress is apparent in many areas, yet it is difficult to isolate those stresses stemming from desertification itself rather than from drought or social and economic change. And evidence for successful adaptation is also present. Little work has been done on the psychological characteristics of much of the non-Western world (an exception is Swift and Asuni, 1975) and full elucidation of the problem awaits further research.

#### D. SUMMARY

115. Desertification is a complex process, and is the product of the interaction of social change with fluctuations in climate and ecosystems. The social processes are usually those associated with modernization and integration of social systems, population shifts, changes in the geopolity and political economy of regions and countries, and the sometimes careless replacement of traditional techniques by industrialized technologies.

116. Natural fluctuations have always occurred in the climates of the dry lands. Both natural ecosystems and older livelihood systems have worked in response to this inherent variability. When these fluctuations are modest and of short duration, their impact on desertification is minor. Climate becomes an active contributor to desertification when abnormally persistent dry or wet periods occur. Drought can lead to desertification by decreasing vegetative productivity and delaying its recovery rates. Ironically, exceptionally wet fluctuations may also promote desertification by encouraging extension of agricultural and pastoral settlement into areas generally too dry to utilize. Wet periods may also encourage an intensified pattern of land use. In both cases, the processes can lead to desertification when the climate reverts to its drier, less productive norm.

117. The most dramatic process of social change is demographic, the rapid change in the number of people utilizing and dependent on the resources of the dry lands. Often imbalances caused by population growth or concentration place increased pressure on the local resource base. When this occurs, the intensified utilization of the resource base without compensating increases in productivity can lead to soil erosion, degradation of

plant cover, groundwater depletion, waterlogging, salinization, elimination of fallow periods, and other phenomena that cause long-term deterioration.

118. Rural depopulation is also a potential contributor to desertification. Out-migration of economically active rural people may increase levels of living in the short term. But in the long run, competition for labour between rural and urban spheres tends to undermine the viability of rural livelihoods which require intensive labour or specialized knowledge. As a consequence, the productivity of their resource base is likely to decline.

119. To the extent that population growth exacerbates desertification, a prolonged worsening of conditions can be anticipated in many rural and most urban areas of the developing world. For industrialized nations the threat posed by population growth is centred on the larger urban areas. Where depopulation contributes to the process, it appears that selected rural areas of developing nations are most threatened by desertification.

120. Demographic trends indicate that population imbalances can be expected to increase in the near future. In the dry rural areas of developing countries, the imbalances will be the product of a steady reduction in death rates without a concomitant reduction in birth rates. Urban populations will grow at even higher rates because of both immigration and local growth. These rates of growth, particularly the urban component, are expected to accelerate in the future as the death rate is further reduced in the countryside and as people move off the land and migrate into urban centres in increasing numbers. Only countries with controlled settlement policies appear able to moderate the rural to urban flows of population by emphasizing the economic viability and social well-being of the countryside.

121. A study of population densities indicates that great variation exists, even among peoples who inhabit homologous climatic regions. The densities reflect the national settings of the dry lands and the great variation in the productivity of the different livelihood complexes employed. The extraordinary range of population densities accommodated within broadly similar climatic zones should discourage facile conclusions about fixed carrying capacities in the dry lands. Conversely, the findings encourage optimism about the flexible and dynamic ability of dry lands to support human populations.

122. A more complex process, and one which has received less careful attention, is the impact that world integration and specialization has had on the traditional livelihood practices and adaptive techniques of dryland peoples. Frequently on the periphery of the world economic system, they are vulnerable to external market forces over which they have little or no control. Often modernization has brought more problems than benefits to these peoples as traditional cultural ecological systems lose their viability and no alternatives take their place. When additional stresses, such as drought, are placed on these systems, it becomes more difficult for them to recover on the basis of their own resources. Yet due to its peripheral status, outside resources are not fully available to aid in recovery. In extreme cases, the productive base may be so degraded that people are forced to abandon their traditional livelihood and habitat entirely.

123. Desertification is also exacerbated by rapid but often incomplete diffusion of unsuitable technologies into traditional societies. Unfortunately, arbitrary implantation of exogenous technologies has triggered processes that have led to long-term loss in the productivity of many dryland areas. In addition, the introduction of such technologies truncates the balanced evolution of indigenous systems of production and desertification

prevention that contain valid, time-tested principles of dryland resource management. The constriction of both livelihood systems and indigenous expertise with proven viability is a serious contributor to the desertification process and a severe handicap in efforts to combat it.

124. The health impact of desertification is more ambiguous. The nutritional mal-effects of decreasing resource base productivity seem straightforward, but little evidence of adjustment to such conditions is presently available. Most existing information relates to drought, an exacerbating factor in desertification, rather than to desertification *per se*. Other diseases also fail to exhibit a close linkage to desertification, being, instead, more directly related to general changes in environment or location or both. The psycho-social stresses experienced by desertification-prone populations are similar to those encountered by most individuals and groups exposed to sudden and rapid change. Their trauma is neither unique nor extreme; indeed, there is evidence to suggest that, provided considerable latitude is available for free choice and for preservation of desired social norms and objectives, the practitioners of traditional livelihoods are capable of adapting successfully to altered conditions.

125. A different type of ambiguity surrounds the role of migration in desertification. In the short term, migration appears to have positive effects; income is increased, extra-regional employment cushions the group from the worst features of local environmental perturbations, and outlets for potentially surplus population are created. Paradoxically, the very success of migrants in adapting to economic opportunity threatens the survival of indigenous livelihood systems. This occurs when labour is shifted into urban and commercial sectors of the economy and the traditional livelihood can no longer maintain basic productivity. The corollary of successful migration often is a weakening of social ties with the home region, a decline in the productivity of the traditional system and an increased marginalization of those who remain behind.

126. A similar array of positive and negative consequences flow from government actions. Often essential to the support of agricultural livelihoods in dry lands, governmental activities are also simultaneously responsible for much desertification. Thus, the government that provides the security, technology, and organization to extend irrigation into new districts often spreads salinization or, by diverting former grazing land to agricultural use, is responsible for increasing desertification pressures on adjacent rangelands. The role of governments in desertification is a chequered one and the very governmental factors that promote use of dry lands often cause their desertification as well.

127. Each of these natural fluctuations and social processes has been identified where desertification occurs. But rarely does one process alone appear to be an adequate explanation for the decline in the productivity of a dry land's resource base. Rather their complex combination and interaction is responsible for most of the world's desertification. Efforts to understand the process and to combat it will be more effective if this causal complexity is recognized.



#### IV. COPING WITH DESERTIFICATION

128. Desertification is inherent to the human use of dry lands and alternating periods of intensification or decline of desert-like conditions are evidenced clearly in their long history. There are many ways in which dryland peoples have learned to cope with desertification, and new techniques are under development. Four principal modes of coping with desertification may be discerned.

##### A. ABSORBING DESERTIFICATION EFFECTS

129. Human livelihood systems are able to absorb some significant degree of desertification with little or no harmful effect. This occurs because ways of coping with desertification are deeply embedded in the everyday functions of livelihood systems. But because they are part and parcel of a way of life, they are difficult to isolate.

130. Sometimes the reduction of hazard occurs incidentally as a byproduct of some other functional purpose. For example, the practice of alternate-year-fallow grazing in irrigated areas of Iraq was basic to animal maintenance in an essentially agriculture-based livelihood. Employment of at least half the arable land in fallow fodder also served, incidentally, to reduce waterlogging and salinization (Gibson, 1974). Abandonment of this practice causes a rapid rise in the watertable with a consequent increase in saline soil levels unless large investments are made in drainage.

131. The most common adaptations are found in the myriad ways in which the culture of dryland livelihood systems copes with threats to, and fluctuations in, its resource productivity. Such everyday practices range from the basic principles of mobility inherent in pastoralism to the tree worship rituals of Rajasthani women that ensure the regular watering of important but exotic desert species. The latter indicates the difficulty in identifying the functionality of resource practice. In the view of the forester, it is a practice that provides shade and species reproduction; in the view of the practitioner, it is a measure of devotion.

132. Taken all together, these different mechanisms provide a livelihood system with a capacity to absorb desertification without much harm. Unfortunately, we have no quantitative estimates of the degree to which a society can suffer the productivity loss of desertification with little or no ill effect. From other hazards, especially drought, we know that short-term losses of up to 10 per cent can be easily coped with.

##### B. ACCEPTING DESERTIFICATION EFFECTS

133. Regardless of the built-in capacity of a system to absorb desertification with little or no harm, such capacity can eventually be exceeded and an awareness of desertification ensues when stress becomes apparent. We know of only one study to date which seeks to identify the perception of desertification by farmers, an opinion survey of 74 farmers in a 10-km wide transect across the 300 mm isohyet in Rajasthan (Malhotra, 1976c). Their perception of fluctuations in traditional wind patterns, degradation of vegetation, soil erosion, and salinization that have taken place over the span of one generation is not only

a measure of the severity of these processes, but is also in accord with current scientific observations.

134. When such awareness develops, the initial response is to *accept* the consequence of desertification. Individuals and societies bear their losses in health, wealth and productivity when they occur, or share them with kin, organized insurance, or community, national and international relief. However, except where acute disaster intersects with desertification, the slow chronic decrease in productivity may get little or no organized attention, leaving the burden to fall on the individuals, communities and regions concerned.

### C. REDUCING DESERTIFICATION CONSEQUENCES

135. A continued decline in productivity cannot be sustained over a long period of time. Individuals and societies act to *reduce* desertification either by modifying or preventing the physical processes or by diminishing the consequences and loss potential.

136. The rich repertoire of techniques to counter dune and sand encroachment, to reduce vegetation degradation and limit the consequent soil erosion, and to prevent waterlogging and salinization is described in the companion review on technology (Anaya-Garduño, 1976). What that review does not address are the social obstacles to adoption of new technologies or developing indigenous areas. Three major obstacles stand in the way of adopting new technologies or furthering the evolution of older ones: difference in perceptions, productive goals, and scale of social organization.

137. No better example of differential perceptions of the desertification problem exists than in comparing the image of erosion held by a technician with that of a traditional dryland farmer. For the technician erosion generally is an unmitigated evil. Whenever deep gullies develop on a denuded hillside the process is seen as one that irrevocably reduces the productivity of that ecological setting. The peasant farmer often does not view erosion as a problem; rather, to him it appears to be a desirable situation replete with opportunities for increasing productivity. Gullies can be blocked by low stone walls and both soil and water concentrated behind the dam (Kirkby, 1973). The fields produced in this manner are more productive, have greater fertility, and, by retaining more moisture, resist drought longer than do cultivated plots on neighbouring hillsides. Similarly, the development of alluvial soils in larger valleys often is enhanced by erosion and richer and flatter fields are developed in the process. It is obvious that the solutions to gullying and erosion proposed by and acceptable to dryland farmers and modern technicians are likely to be very different and may well be mutually incompatible.

138. Even where desertification and the technique for coping with it are similarly appraised, difference in acceptance may be great because of different goals or capabilities for change. Plant cover, an integral component of dune stabilization, often serves a dual function in people's livelihood systems as a source of firewood, forage, and food. In times of stress a tension occurs between people's needs and the sound management principles detailed in the companion review on ecological change (Warren and Maizels, 1976). Other adjustments, such as enclosures or the barring of cultivation in areas perceived as marginal, while serving sound ecological ends, may also imply heavy individual and social costs due to the fact that these measures entail a short- or long-term loss of access to a crucial resource base for needy populations.

139. Finally, to be efficacious new techniques require certain scales of application. For

example, since wind is capable of transporting enormous quantities of sand or soil (McGinnies, McComb and Fletcher, 1963), combating sand encroachment can be a laborious and costly proposition, often beyond the means of a single family or community. Therefore, successful large-scale efforts based on local self-reliance entail a supportive national structure, as is the case in the People's Republic of China (Whitney, 1976). In other cases, efforts on a smaller scale may be undertaken by single entrepreneurs only with the aid of capital and energy-intensive equipment (Heathcote and Williams, 1976).

140. Efforts can be taken not only to reduce the physical processes of desertification, but also its consequences. In coping with the consequences of reduced nutritional intake, people can do less work, resort to famine foods, seek outside relief, or develop hostile, atomistic, but self-preserving, interaction patterns. While each of these alternatives is widely resorted to in times of crisis, none is a viable long-term solution since this would entail intolerable levels of pathology and dependency.

141. A much more common response to declining yields and the lowered nutritional intake that these entail is a resort to seasonal labour or handicraft manufacture. In many dryland livelihood complexes, these two alternatives are already worked into the productive system (e.g., Johnson Haring, 1976a). However, when desertification lowers the productivity of farming or husbandry, people must rely on the other options open to them. In extreme cases, this may mean that people lose control over their productive base and become impoverished craftspeople or landless wage labourers. In wealthy countries, in response to declining yields, there is a continuing enlargement of the productive unit. This, in turn, requires a high capital investment to operate the enlarged unit without more labour. While this enables the entrepreneur to maintain net economic return in the face of declining productivity, it is seldom an option that is available to the bulk of a population exposed to desertification.

#### D. CHANGES IN USE OR LOCATION

142. Finally, more important to coping with desertification than to other hazards are *changes* of livelihood or location or both. Historically, the responses of people to desertification have involved such changes in contrast to direct efforts to combat desertification. Thus, herds were reduced or moved, nomads without animals became sedentarized, and long-fallows were practised to allow for natural recovery; alternately, and less frequently, efforts were increased to intensify production through irrigation.

143. The most drastic of all changes is permanent abandonment. Whenever people abandon land, they turn to urban or rural wage labour, small or large commercial ventures, or attempt to enter the bureaucracy. This social mobility is as much a basic response to the unpredictability of an arid ecosystem as the livelihood movements described in previous sections of this report. Whether or not this mobility represents an adjustment that is beneficial to the individual or the social group very much depends on the circumstances where it takes place; there is no one generalization that will cover the range of this adjustment. Pastoral nomads who have lost their herds, and who now subsist in what were to be temporary food distribution centres, represent a case where change has led to a (at least temporary) dead end. On the other hand, peasants who are forced to leave a countryside that no longer provides a basis for their sustenance can find work, and often prosper, in cities.

144. In any society, the particular mix of coping modes is related to the wealth and technology available to reduce desertification as well as to the alternative livelihoods and locations available to the people undergoing desertification. The profiles of response (Fig. 6) present an impression of the relative effort in terms of both social costs of adjustment and the consequences suffered for four different livelihood systems. No monetary value is assigned to the cost axis, although for many elements of that component such values could be developed. The social effort required to cope with desertification can be measured in terms of crop losses sustained, relief aid given, person-hours of administrative attention consumed, insurance policies purchased and so on. Far more difficult to quantify are the costs associated with relocating in new settings, the stress placed on individuals when traditional social support mechanisms no longer function, or the strains experienced when adjustment to new livelihoods must rapidly be undertaken.

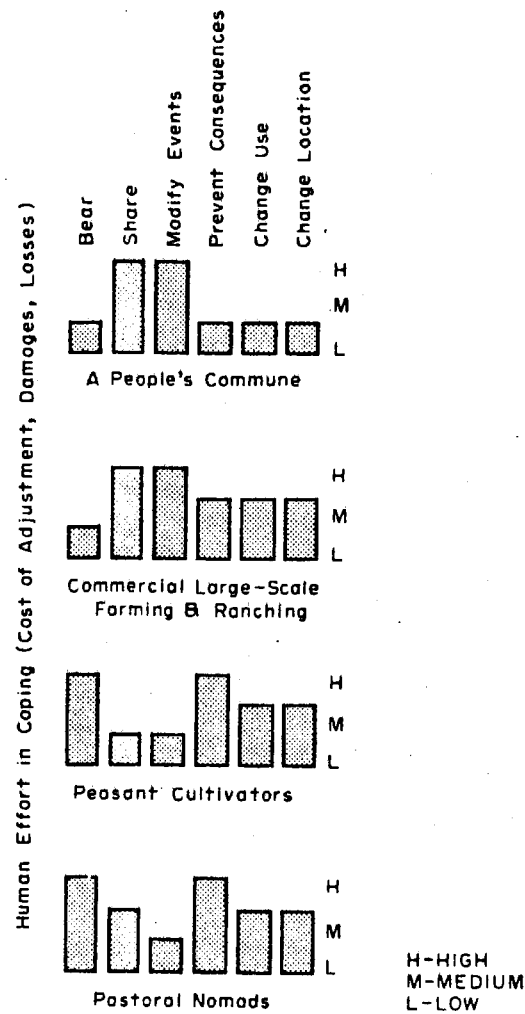


Fig. 6. Adjustments to desertification: examples from four different livelihood systems

145. Thus, the scale of social costs is selective and impressionistic as there are no basic economic studies of desertification. However, they are partly based on two analogous and related sets of studies: drought adjustment and soil erosion. From studies of agricultural drought adjustment in Australia and Tanzania (Burton, Kates and White, forthcoming), we know that the ongoing costs of reducing drought vulnerability and the average residual drought losses are about equal, total average costs per person at risk being about \$1.50 (U.S.) in Tanzania and \$43.00 (U.S.) in Australia. While the Australian costs and losses are 30 times greater than those of Tanzania in absolute terms, the reverse is true in relative terms (per cent of per capita GNP). This reflects the greater seriousness of drought in developing countries. Desertification costs and losses are likely to evidence a similar pattern.

146. The second set of studies relates to soil erosion. In the most comprehensive review to date and available only for a developed country, the United States, Held and Clawson found in 1965 that the U.S. had spent some 9 billion dollars on soil conservation over a 30-year period. Using a variety of sources, they found that neither the physical accomplishment of that expenditure nor its economic benefits (if any) were assessable. At best, they could conclude that only 20-60 per cent of the needed effort to reduce soil erosion in the U.S. from 1930s levels had been accomplished. As to economic payoff, they concluded that in the absence of further subsidy there was little profit potential in soil conservation. Indeed, in many cases there would be losses to the farmers concerned.

147. The absence of comprehensive cost and loss data would imply a need to encourage such studies as preliminary to international efforts to combat desertification. But as in many such assessments, the costs will be more easily defined than the benefits (the losses to be averted). This recurrent problem of economic evaluation is the most serious deficiency in desertification study, given its poorly examined, slow, cumulative, and long-term effects on productivity.

#### E. SUMMARY

148. People cannot have been passive in the face of desertification and still have survived in the dry lands, the oldest of humankind's habitats. Ways of coping with desertification are built into existing livelihood systems, into the expectation and acceptance of fluctuating fortune, into a wide range of techniques to combat desertification and reduce its consequences, and into the willingness to move or to adapt to new livelihoods.

149. Thus all livelihood systems have a limited capacity to absorb some measure of desertification without suffering significant consequences. Cultural adaptations, part and parcel of everyday life, serve to buffer slowly evolving losses of productivity. And given the fluctuations in well-being characteristic of dryland livelihoods, productivity losses, even when apparently harmful, may be accepted for long periods of time.

150. But in the long run, continued loss of productivity and threats to life and livelihood evoke active responses, some to combat the physical processes of desertification, others to provide an alternative focus on places or livelihoods. Historically, changing land use, building irrigation works, reducing or moving herds, instituting long fallows, and allowing for natural recovery were more common or effective responses than human

initiative to restore productivity or reverse desertification. The mix of coping modes utilized in a livelihood system is related to available wealth and technology. Today technological advances in methods of prevention and restoration, and increases in the scale of social organization, make possible, but do not ensure, a broadened range of human response.

## V. MAJOR FINDINGS AND IMPLICATIONS FOR ACTION

151. Desertification poses a serious threat to the livelihoods of an estimated 78 million people living in severely or very severely desertified areas; 50 million of this total are directly affected by the loss of resource base productivity. Most of these are numbered among the poorest peoples or are inhabitants of the poorer nations. To a degree, they are victims of an environmental hazard not of their own making, and one that will increase considerably over the next two decades. Thus, it is fitting that an international forum be developed to examine this threat, to attend to the plight of its victims, and to organize assistance and preventive action.

152. But while the numbers and areas affected may be large, they are the aggregate of many different environmental and human conditions. Desertification is a complex environmental hazard and vulnerability to it is highly selective. Its physical processes are varied, its causes are multiple, and its consequences are subtle and long-term. Desertification is a human phenomenon, more a social, economic and political problem than a technical one.

153. This complexity is the major finding of our review. It should caution those who would expand on the popular myth of a world-wide problem of advancing deserts, those who would propose universal actions or facile prescriptions. It should inform the international community concerned with desertification of the need to be selective in choice of problems to be addressed, to be flexible in terms of measures proposed, and to be sustained in terms of the efforts undertaken.

### A. ASSIST THE MOST VULNERABLE

154. The limited resources of nations and the international community need to be directed towards reducing the threat for the most vulnerable peoples. These groups should be the target of assistance because desertification's impact on them is proportionately greater than it is on more secure peoples and because their resources are insufficient to provide a flexible, multi-option response to desertification. Among nations, the most vulnerable are developing nations undergoing more or less rapid change in population, technology, and land use and who are primarily dependent on dryland resources. Within nations, the most vulnerable peoples are those dependent for their livelihoods on agriculturally marginal lands, and those who by virtue of location, ethnicity or class are peripheral to centres of power, assistance, and investment.

155. The 50 million people directly undergoing desertification are not uniformly distributed across the dry lands nor are they simply chance victims of natural settings or climatic fluctuations. They are rarely found in industrialized countries such as Australia, the Union of Soviet Socialist Republics or the United States, where impressive progress has been observed in overcoming earlier problems. Nor, for the most part, are they in the extremely arid zone, in the mineral-rich nations, or in countries in which population, land use, and technology are changing slowly.

156. The greatest vulnerability to desertification occurs selectively within nations. The reduction in productivity of dryland resources characteristic of desertification affects mostly those whose diets are already inadequate or whose land and water resources are

currently limited. Such constraints may overcome the ecological advantage of certain livelihoods. For example, animal-based livelihoods, which by virtue of their mobility are ecologically least prone to desertification, may become vulnerable as their relative access to resources is increasingly constrained. Conversely, the intense desertification that accompanies urbanization, or the waterlogging and salinization that follows from irrigation, may be offset by the diverse opportunities cities provide or the heavy investment devoted to irrigation.

157. The implications of this vulnerability analysis run counter to proposals that would address desertification problems in all of the dry lands or whenever the physical signs of desertification are observed. Instead, it would urge the international community to direct assistance to the most vulnerable nations, and would encourage nations to direct their attention to their most vulnerable peoples rather than to the most desertified areas. To do so, a more detailed vulnerability analysis, as sensitive to the social, economic, and political contexts of people and their livelihoods as to measures of physical process, is the first step needed in order to target international and national efforts to combat desertification.

#### B. ADDRESS THE ROOT CAUSES

158. Desertification is a human phenomenon. It inevitably arises from the need or desire to subsist upon, improve, or exploit the land and water resources of the dry lands. While some degradation in the natural environment is surely acceptable, when the immediate benefits outweigh the costs, much of it threatens the long-term well-being of the people whose livelihoods are dependent on these resources. Such desertification usually arises from two sets of imbalances in the human use of dry lands: (1) those related to population growth, decline and movement, and (2) those related to the introduction or abuse of technologies, or new land uses and economic ties. These imbalances are further exacerbated and intensified when they coincide with detrimental climatic fluctuations. If efforts to combat desertification are to be more than palliatives, they need to be addressed to the root causes of these imbalances.

159. Such a task is not a simple one. The causes of these imbalances are multiple and contradictory. Population decline as well as growth can lead to desertification. New technologies can combat desertification or induce it. The major impetus for desertification may stem from the livelihood practices within a region or from policies and practices adopted in centres far from the dry lands. Finally, the most careful plans and practices may prove inappropriate in the face of short-term natural fluctuations of climate and vegetation.

##### 1. Population Growth, Decline, and Movement

160. In a global context, the notion of a generalized carrying capacity for dry lands, which when exceeded leads to desertification, seems chimerical. Population densities and trends vary widely in similar climatological zones and the tendency to equate desertification with numbers of people or animals at best oversimplifies and thereby obscures the origins of desertification. At its worst, it seeks to shift the responsibility from desertification onto its victims. Indeed, an important finding of this demographic review is how selective loss of the agriculturally active population can serve to encourage desertification.

161. Regions with a potential for desertification can anticipate further population



growth due to the fact that their birth rates remain high despite improvement in reducing death rates. In developing countries, rural population will increase by 2 per cent to 3 per cent per year. This is a growth rate which can be absorbed in very few dry rural or urban areas without causing environmental disruption and human problems. Yet, given the values of many peoples and their governments, sudden change to a low birth/low death pattern is unlikely, and many dry lands will be forced to accommodate high growth rates for many years. This indicates that for many regions more desertification, not less, is the likely immediate prospect.

162. For many of the rural people, the vast majority of whose lives are sustained by agriculture, life in the countryside will remain economically and socially viable. However, millions of others will migrate to urban centres in both dry lands and beyond. Where this out-migration is composed largely of labouring males, the loss of agriculturally active population may well result in a loss of productivity in the rural environment. Terraces no longer maintained may collapse, leading to soil erosion; in the absence of herders, animals may be sold; loss of specialized labour may result in lower yields from orchard crops and abandonment of farm land. Conversely, these effects may be compensated by remittances that lead to productive investment, by the substitution of gas or oil for charcoal as a fuel source, and by opportunities to supplement domestically produced foodstuffs.

163. Related to this issue of the loss of labour in agricultural societies are restrictions on the movement of pastoralists and fishing peoples. In the interests of national sovereignty, there are often rigid controls placed on population movement from one territory to another. Pastoralists and fishing peoples have experienced particular problems in this regard, since the national boundaries inherited from the colonial era often cut across natural ecosystems and ethnic and livelihood regions. The importance of free movement across such lines becomes particularly apparent during droughts when it becomes difficult, if not impossible, to escape to districts that traditionally were available.

164. Movement and migration policies should be placed at the centre of efforts to combat desertification in preference to population control policies (an exception being South Asia). It should be recognized that continued outflow of population from arid lands will take place in most developing countries. Attention should focus on how best to prepare and facilitate such migration, where appropriate, particularly by youth, and effort is needed to encourage remittances for productive investment in their home areas. The cause of such movements lies in the disparities between dry lands and the centre, disparities which must be addressed by efforts to create viable social and economic alternatives in the area of origin. In this regard, the experience of some planned economies as well as the methods of compensatory subsidy support found in many market countries should be carefully studied. International agreements should be negotiated to facilitate movement by pastoralists and fishermen, particularly in periods of stress.

## 2. New Technologies, Land Uses and Economic Ties

165. Integration into a world market economy frequently has brought more problems than benefits to countries and regions subject to desertification. These areas are often located within the underdeveloped periphery of the world system, or the under-developed region of a nation-state. Thus, they are vulnerable to external market forces over which they have little or no control. Historically, the needs and problems of the developed, highly industrialized countries or regions at the centre of the world market system have

dictated the path and pace of development in the periphery. This development entails the modernization, i.e. destruction, of traditional, self-sufficient livelihood systems and, in this sense, plays an important role in the dynamics of desertification. As traditional societies in peripheral arid regions undergo a process of disintegration, and as old productive strategies and exchange patterns become unviable options, both the natural and the cultural components of the ecosystem deteriorate. When additional stresses, such as drought, are placed upon the system, it becomes hard for it to recover on the basis of purely indigenous resources. Yet, due to its still peripheral status, outside resources do not readily flow in upon demand, further hampering recovery. In extreme cases, the productive base may have become so degraded that people are forced to abandon their old livelihoods and habitats.

166. It is not clear that this is a historically necessary pattern. With the introduction of new technologies, indigenous ones are in retreat. But paradoxically, the loss of these systems comes at a time when there is growing recognition of their inherent original rationality and ecological wisdom. Acknowledgement of this characteristic of traditional systems is not based solely on appreciation of their longevity. Rather, the ability to use marginal resources in ways that are ecologically astute and that are efficient in energy terms seems especially important. Any system capable of reducing or avoiding fossil fuel inputs represents a substantial saving to the total socio-economic system.

167. Not only does the introduction of new technologies truncate the evolution of indigenous systems, but the former seldom fulfil their own promise. There seems to be an inevitable and endemic lag in the transfer process in which only central functions of the new technology are transferred without the necessary complements. For example, irrigation water is introduced without sufficient drainage leading to salinization, or mechanized ploughing is promoted without the benefit of conservation farming resulting in the loss of topsoil due to aeolian action.

168. New land uses or economic ties have a similar effect. Export crops with cash returns capture the available resources of the agricultural enterprise and reduce the traditional "normal surplus" of food production. This often creates famine where before there were shortages in slightly less-favourable years. Single crop productive systems replace traditional systems without the complementary handicraft or collecting activities that enriched the traditional livelihoods. Industrialized countries are also not immune to similar problems for the use of their arid lands becomes subject to distant market forces or competitive production.

169. Several implications follow from these observations. Development projects in dry lands should be stringently assessed for their impact on desertification. Indigenous technologies and productive systems require sympathetic study to identify opportunities to support their evolution. New technologies and land uses need critical appraisal to identify needed complements without which desertification and its consequences would be increased. In general, maintaining the viability of diversified livelihood systems should take precedence over the optimization of any single product system.

### C. COPE WITH THE CONSEQUENCES

170. The major consequences of desertification are the loss of productivity of the resource base, the threat to the health and well-being of people at risk, and the problems to populations that arise from desertification-induced migration and resettlement.

### 1. Loss of Productivity

171. A long-term chronic decline in productivity of the resource base is the most serious manifestation of desertification, yet its direct social and behavioural effects are poorly understood. It is clear, however, that societies possess strategies that help them cope with the losses in productivity which are caused by desertification. Some of these strategies serve to stay or reverse the deterioration of the resource base, some develop new patterns of use of existing resources, while others involve total changes in livelihood and location. Although most societies adopt a range of these coping strategies, certain characteristic modes of coping can be distinguished, depending on societal wealth and level of organization. For example, agriculture-based societies possessing sufficient capital and organization transform dryland use by the introduction of irrigation, or they enlarge the scale of operations by increasing the inputs of land and capital. Individual peasant agriculturalists, who characteristically have access to neither land nor capital, commonly resort to labour out-migration or to handicraft manufacture using locally available materials. Pastoralists may abandon nomadism altogether and become farmers or urban workers.

172. In general, and with the exception of the wealthy industrial nations, conditions favourable to individual efforts directed at land restoration do not exist among the populations vulnerable to desertification. Programmes aimed at stemming loss of productivity and restoration of land in the developing world will necessarily involve capital input from sources outside the affected areas. These investments yield maximum social benefits if they are used in such a manner as to complement existing coping strategies and thereby reinforce the viability of rural life. Therefore, land reclamation and rural infrastructure projects which emphasize the use of local materials and local labour, as well as focus on developing collective solutions to collective needs, should be given priority over other alternatives.

### 2. Health and Well-Being

173. The health and well-being of individuals and livelihood systems are adversely affected by desertification, but there is little evidence that directly links health problems to increasing aridity. The health consequences of desertification are invariably indirect and, hence, difficult to measure. Lower nutritional intake, however, is a direct consequence of desertification and, for vulnerable populations, it may have serious repercussions on health.

174. Diseases associated with arid areas, such as trachoma or pulmonary infirmities, are serious problems that persist in arid areas, requiring changes in land use, water availability, and health care to reduce them. Except in so far as wind-borne dust may increase the incidence of eye infections, respiratory irritation, and associated diseases, evidence for a direct causal linkage between desertification and disease is lacking.

175. Most diseases commonly associated with desertification are in fact a consequence of drought or human migration. In the case of the latter, the first contact health problems are of the kind to be expected whenever an isolated population is brought into close association with otherwise alien diseases. For these public health problems, and for sanitary difficulties linked to population concentration, knowledge of the appropriate

remedial measures is well understood by national officials and international agencies. Drought-induced health problems are also well-known, the signs of nutritional deficiency are generally unambiguous, and the unequal pattern of mortality that strikes the aged, the infirm, and the young is well established.

176. Additional health problems associated with desertification are those related to psycho-social stresses. These are most serious in acute situations such as drought or resettlement involving new environmental settings or an unfamiliar livelihood. There is little evidence for similar pressures being present in chronic desertification; indeed, where such change is gradual there is reason to believe that the adaptive capacity of culture and livelihood will facilitate the development of effective coping mechanisms.

177. Specific attention to the health problems of scattered and marginal populations is justified on both general development and humanitarian grounds. This can best be accomplished by adopting strategies which place the primary responsibility for the initial stages of health care on trained indigenous individuals and which selectively use modern transportation and communications technology to move serious cases to centralized medical facilities. It is important for planners to take into account the probability that the initial effect of this health care improvement will most likely be a reduction in the death rates and a consequent increase in population.

### 3. Migration, Relocation and Livelihood Change

178. The major response of livelihood systems to chronic desertification is migration and/or change in basic livelihood patterns. The role that such shifts in location and livelihood play in traditional systems varies. For some, migration is the only alternative; for others, seasonal mobility is a fundamental part of long-term adaptation; for still others, it is a positive response to new opportunities. Because population growth can be expected to continue in dry lands for the foreseeable future, provision for the accommodation of some of this increase outside desertification-prone districts will have to be made. Most of these migrants will be individuals or family units rather than entire social groups and assistance provided should prepare participants at both ends of the migration continuum to cope with the often rapid required changes.

179. Action programmes supportive of migration's adaptive elements should take into account the following three areas: (1) Education developed to combat desertification must incorporate relevance to local concerns as its paramount objective. In order to be effective, education must, therefore, focus on techniques for increasing the productivity of local resource systems, as well as develop programmes that prepare individuals with skills that enable them to find employment outside desertified areas. (2) In all cases, it is essential to incorporate the people most affected by desertification in meaningful decision-making roles. The best measure of the desirability of an anti-desertification project should be the willingness of local people to participate in it. Formal education and propaganda are inadequate as substitutes for genuine participation. (3) Resettlement where necessary can be carried out in ways that minimize psycho-social stress if the following principles are used. Economic viability is the crucial variable in determining the success of a project: other considerations are secondary. Projects of a design and scale that maintain cultural and social integrity, as well as maximize local participation in decision-making, will minimize the negative effects of relocation.

180. To facilitate migration and to reduce its burdens, there is need to develop in the short-run meaningful forms of local participation, in the medium-run selective economically-viable resettlement opportunities, and in the long-run effective work-related educational programmes.

## BIBLIOGRAPHY

- Aart, R. van (1971) *Aspects of Land Use Planning in the Lower Mesopotamian Plain: A Problem Analysis*. Technical Report No. 33. Abu Ghraib, Iraq: Institute for Applied Research on Natural Resources.
- Abu-Lughod, Janet (1961) Migrant adjustment to city life: the Egyptian case, *American Journal of Sociology*, lxvii: 22-32.
- Adams, Robert McC. (1965) *Land Behind Baghdad: A History of Settlement on the Diyala Plains*. Chicago: University of Chicago Press.
- Adams, Robert McC. (1974) Historic patterns of Mesopotamian agriculture, in *Irrigation's Impact on Society*, Theodore E. Downing and McGuire Gibson, eds., Tucson: University of Arizona Press, pp. 1-6.
- Ahmed, Abdel Ghaffar M. (1973) Nomadic competition in the Funj Area, *Sudan Notes and Records*, liv: 43-56.
- Anaya-Garduño, M. (1976) *Desertification and Technology*. Preliminary Draft Report prepared for the United Nations Conference on Desertification.
- Australia. Commonwealth Bureau of Census and Statistics (1973) *Demography*, Canberra: Commonwealth Bureau of Statistics.
- Benyoussef, J. et al. (1974) Health effects of rural-urban migration in development countries: Senegal. *Social Science and Medicine*, viii: 243-258.
- Berg, Elliott (1975) *The Recent Economic Evolution of the Sahel*. Ann Arbor: University of Michigan, Centre for Research on Economic Development.
- Berry, Leonard and Robert W. Kates (1972) Views on environmental problems in East Africa, *The African Review*, ii: No. 3, 299-314.
- Bowden, Martyn J. (1976) No dustbowl in the future: saying nay to doomsday in the North American Great Plains. MS prepared for Supplementary Materials to *Population, Society and Desertification*.
- Brooks, Reuben H. (1976) The peasant farmer of the Sertão of Taua, Ceara, Northeast Brazil, in *Profiles of Change*, Supplementary Materials to *Population, Society and Desertification*.
- Burton, Ian, Robert W. Kates and Gilbert F. White (forthcoming) *The Environment as Hazard*. New York: Oxford.
- Caldwell, John C. (1975) *The Sahelian Drought and its Demographic Implications*. OLC Paper No. 8. Washington, D.C.: Overseas Liaison Committee, American Council on Education.
- Campbell, David (1976a) A nomadic family in Niger, in *Profiles of Change*, Supplementary Materials to *Population, Society and Desertification*.
- Campbell, David (1976b) *Strategies for Coping with Drought in the Sahel: A Study of Recent Population Movements in the Department of Maradi, Niger*. Ph.D. Dissertation, Clark University, Graduate School of Geography, Worcester, Massachusetts, U.S.A.
- Chen, Cheng-Sian (1973) Population growth and urbanization in China 1953-1970, *Geographical Review*, lxiii: 55-72.
- CONAZA (n.d.) Report on Mexico's arid lands. Unpublished MS. Mexico D.F.: Comisión Nacional de las Zonas Áridas.
- Cossins, Noel J. (1971) *Pastoralism Under Pressure: A Study of the Somali Clans of the Jijugga Area of Ethiopia*. Addis Ababa.
- Cossins, Noel J. (1972) *No Way to Live: A Study of Afar Clans of the North-East Rangelands Carried Out for the Livestock and Meat Board of the Imperial Ethiopian Government*. Addis Ababa: North-East Rangelands Development Project.
- Darling, F. Fraser and Mary A. Farvar (1972) Ecological consequences of sedentarization of nomads, in *The Careless Technology: Ecology and International Development*, M. Taghi Fatvar and John P. Milton, eds., Garden City, New York: Natural History Press, pp. 671-682.
- Davis, Kingsley (1969) *World Urbanization, 1950-1970. I: Basic Data for Cities, Countries and Regions*. Population Monograph Series No. 4. Berkeley, California: University of California, Institute of International Studies.
- Dow, Michael (1975) *Trip Report: Visit to Sana'a, Yemen Arab Republic, December 2nd-8th, 1975*. Mimeo.
- Draz, O. (1974) *Report to the Government of the Syrian Arab Republic on Range Management and Fodder Development*. United Nations Development Programme No. Ta 3292. Rome: United Nations, Food and Agriculture Organization.
- Dregne, Harold (n.d.) *Desertification: a worldwide phenomenon*. MS.

- Ekholm, Erik P. (1976) *Losing Ground*. New York: W. W. Norton.
- EMASAR (1975) *The Ecological Management of Arid and Semi-Arid Rangelands in Africa and the Near and Middle East*. Rome: United Nations, Food and Agriculture Organization.
- Ivenari, Michael, Leslie Shanan and Naphtali Tadmor (1971) *The Negev: The Challenge of a Desert*. Cambridge, Mass.: Harvard University Press.
- Fahmi, Adnan S. M. (1976) Personal communication, Acting Director Palm and Dates Research Centre, Baghdad, Iraq, May 9, 1976.
- Faulkingham, Ralph H. (1976) Alasan and the drought: a case study from Niger, in *Profiles of Change, Supplementary Materials to Population, Society, and Desertification*.
- Ferneau, Robert A. (1970) *Shaykh and Effendi: Changing Patterns of Authority among the El-Shabana of Southern Iraq*. Cambridge, Mass.: Harvard University Press.
- Fox, David J. (1965) Man-water relationships in Metropolitan Mexico, *Geographical Review*, lv: 523-545.
- Gebre-Medhin, Mehari (1974) Famine in Ethiopia, *Ethiopian Medical Journal*, xii: 105-107.
- George, Carl J. (1972) The role of the Aswan Dam in changing the fisheries of the Southeastern Mediterranean, in *The Careless Technology: Ecology and International Development*, M. Taghi Farvar and John P. Milton, eds., Garden City, New York: Natural History Press, pp. 160-178.
- Gibson, McQuire (1974) Violation of fallow and engineered disaster in Mesopotamian civilization, in *Irrigation's Impact on Society*, Theodore E. Downing and McQuire Gibson, eds., Tucson: University of Arizona Press, pp. 7-19.
- Glantz, Michael H. Ed. (1976) *The Politics of Natural Disaster: The Case of the Sahel Drought*. New York: Praeger.
- Graves, Nancy B. and Theodore D. Graves (1974) Adaptive strategies in urban migration, *Annual Review of Anthropology*, iii: 117-151.
- Greene, Mark (1975) Impact of the Sahelian drought in Mauritania, *African Environment*, i: No. 2, 11-21.
- Hansis, Richard A. (1976) Viticulture in the Mendoza oasls, Argentina, in *Profiles of Change, Supplementary Materials to Population, Society, and Desertification*.
- Harris, Chauncey, D. (1971) Urbanization and population growth in the Soviet Union, 1959-1970, *Geographical Review*, lxi: 102-124.
- Heady, Harold F. (1972) Ecological consequences of Bedouin settlement in Saudi Arabia, in *The Careless Technology: Ecology and International Development*, M. Taghi Farvar and John P. Milton, eds., Garden City, New Jersey: Natural History Press, pp. 694-711.
- Heathcote, R. L. (1969) Drought in Australia: a problem in perception, *Geographical Review*, lix: 175-194.
- Heathcote, R. L. and M. Williams (1976) The Mallee of South Australia, in *Profiles of Change, Supplementary Materials to Population, Society, and Desertification*.
- Held, R. Burnell and Marion Clawson (1965) *Soil Conservation in Perspective*. Baltimore: Johns Hopkins Press for Resources for the Future, 1965.
- Henderson, H. Francis (1974) *Current State of the Fish Stocks of Lake Kossou*. Rome: United Nations, Food and Agriculture Organization.
- Hewitt, Ken (1976) Problems of aridity in Pakistan, in *Profiles of Change, Supplementary Materials to Population, Society, and Desertification*.
- Horowitz, Michael M. (1972) Ethnic boundary maintenance among pastoralists and farmers in the Western Sudan (Niger), in *Perspectives on Nomadism*, William Irons and Neville Dyson-Hudson, eds., Leiden: E. J. Brill, pp. 105-114.
- Jacobsen, Thorkild (1960) The waters of Ur, *Iraq*, xxii: 174-185.
- Jacobsen, Thorkild and Robert M. Adams (1958) Salt and silt in Ancient Mesopotamian agriculture, *Science*, cxxviii: No. 3334, 1251-1258.
- Johnson, Douglas L. (1973) *Jabal al-Adkhdar, Cyrenaica: An Historical Geography of Settlement and Livelihood*. Chicago: University of Chicago, Department of Geography, Research Paper No. 148.
- Johnson Haring, Kirsten (1976a) The Otomi of the Mezquital Valley, Hidalgo, Mexico, in *Profiles of Change, Supplementary Materials to Population, Society, and Desertification*.
- Johnson Haring, Kirsten (1976b) *Do As the Land Requests: A Study of Otomi Resource-Use on the Eve of Irrigation*. Ph.D. dissertation, Clark University, Graduate School of Geography, Worcester, Massachusetts, U.S.A.
- Kassas, M. (1972) A brief history of land-use in Mareotis Region, Egypt, *Minerva Biologica*, i: No. 4, 167-174.
- Kates, Robert (1972) The hazard of drought, in *Patterns and Perspectives in Environmental Science*, Washington, D.C.: National Science Foundation, pp. 218-221.
- Kirkby, Anne V. T. (1973) *The Use of Land and Water Resources in the Past and Present Valley of Oaxaca, Mexico. Prehistory and Human Ecology of the Valley of Oaxaca*, Vol. 1. Ann Arbor: Memoirs of the Museum of Anthropology, University of Michigan No. 5.

- Lagler, Karl F. (1973) *A Review of the Lake Kossou Fishery Development Project, Ivory Coast*. Rome: United Nations, Food and Agriculture Organization.
- Laya, Diulde (1975) Interviews with farmers and livestock-owners in the Sahel, *African Environment*, 1: No. 2, 49-93.
- Lee, Richard B. (1969) !Kung bushman subsistence: an input-output analysis, in *Environment and Culture*, Andrew P. Vayda, ed., Garden City, New York: Natural History Press, pp. 47-79.
- Lec, Richard and Irving DeVore (1968) *Man the Hunter*. Chicago: Aldine.
- LeHouérou, H. N. (1968) La désertisation du Sahara septentrional et des steppes limitrophes (Libya, Tunisie, Algérie), *Annales Algériennes de Géographie*, 3me Année, No. 6, 5-30.
- Lickiss, J. Norelle (1975) Health problems of urban aborigines: with special reference to the aboriginal people of Sydney, *Social Science and Medicine*, ix: 313-318.
- Lier, R. A. J. van (n.d.) *Report Concerning the FAO/UNDP Project for Strengthening the Awash Valley Authority (Ethiopia 11)*. Rome: United Nations, Food and Agriculture Organization.
- McGee, T. G. (1973) Peasants in the cities: a paradox, a paradox, a most ingenious paradox, *Human Organization*, xxxii: No. 2, 135-142.
- McGinnies, W. G., A. L. McComb and J. E. Fletcher (1963) Role of watersheds and forests in the arid west, in *Aridity and Man*, C. Hodge and P. C. Duisberg, eds., Washington, D.C.: American Association for the Advancement of Science, pp. 277-307.
- MacGregor, Maria T. G. de and Carmen Valverde V. (1975) Evolution of the urban population in the arid zones of Mexico, 1900-1970, *Geographical Review*, lxxv: 214-228.
- Malhotra, S. P. (1976a) Demographic, social and behavioural attributes and their impact on desertification in arid zones of Rajasthan. Unpublished MS. Jodhpur: Central Arid Zone Research Institute.
- Malhotra, S. P. (1976b) A case study among Bishonis, Chirai Village, Jodhpur District, in *Profiles of Change*, Supplementary Materials to *Population, Society, and Desertification*.
- Malhotra, S. P. (1976c) Opinion survey on desertification, a case study. Unpublished MS. Jodhpur: Central Arid Zone Research Institute.
- Malhotra, S. P., L. P. Bharara and F. C. Patwa (1976d) Introduction of irrigation in arid Rajasthan: a case study, in *Problems in the Development and Conservation of Desert and Semidesert Lands*. Twenty-Third International Geographical Congress, Working Group on Desertification in and around Arid Lands, Pre-Congress Symposium K-26, Ashkhabad, USSR, July 20-26, pp. 115-118.
- Mangin, William, ed. (1970) *Peasants in Cities: Readings in the Anthropology of Urbanization*. Boston: Houghton Mifflin.
- Meckelein, W. (1976) Desertification caused by land reclamation in deserts: the example of the New Valley, Egypt, in *Problems in the Development and Conservation of Desert and Semidesert Lands*. Twenty-Third International Geographical Congress, Working Group on Desertification in and around Arid Lands, Pre-Congress Symposium K-26, Ashkhabad, USSR, July 20-26, pp. 151-153.
- Meigs, Peveril (1953) World distribution of arid and semi-arid homoclimates, in UNESCO, *Arid Zone Hydrology*. Arid Zone Research No. 1. Paris: United Nations, Educational, Scientific and Cultural Organization, pp. 203-209.
- Melamid, Alexander (1965) Political boundaries and nomadic grazing, *Geographical Review*, lv: 287-290.
- Mitchell, J. Clyde (1969) Structural plurality, urbanization and labour circulation in Southern Rhodesia, in *Migration*, John A. Jackson ed., London: Cambridge University Press, pp. 156-180.
- Morris, Arthur S. (1969) The development of the irrigation economy of Mendoza, Argentina, *Annals Association of American Geographers*, lxx: 97-115.
- Nechayeva, N. T. (1976) Influences of anthropogenic factors on the ecosystems of the deserts of Central Asia, in *Problems in the Development and Conservation of Desert and Semidesert Lands*. Twenty-Third International Geographical Congress, Working Group on Desertification in and around Arid Lands, Pre-Congress Symposium K-26, Ashkhabad, USSR, July 20-26, pp. 125-129.
- Nolan, Riall (1975) Labour migration and the Bassari: a case of retrograde development, *Man*, x: No. 4, 571-588.
- O'Keefe, Philip (1975) Gakarara: a study in the development of underdevelopment, Occasional Paper No. 6, Disaster Research Unit, University of Bradford.
- Omolalu, A. (1976) Personal communication, June 2, 1976.
- Ormerod, W. E. (1976) Ecological effect of control of African Trypanosomiasis, *Science*, cxcix: No. 4229 (27 February), 815-821.
- Petrov, M. P. (1976) *Deserts of the World*. New York: Halsted.



- Peyre de Fabregues, B. (1973) *Synthèse des études de la zone de modernisation pastorale du Niger: amélioration de l'exploitation pastorale*. Paris: Institut d'étude médecine vétérinaire des pays tropicaux.
- Picardi, Anthony C. and William W. Seifert (1976) A tragedy of the Commons in the Sahel, *Technology Review*, lxxviii: No. 6, 42-51.
- Rapp, Anders (1974) *A Review of Desertification in Africa: Water, Vegetation, and Man*. Stockholm: Secretariat for International Ecology, Sweden.
- Redfield, Robert (1956) *Peasant Society and Culture*. Chicago: The University of Chicago Press.
- Reyna, A. P. and Christian Bouquet (1975) Chad, in *Population Growth and Socioeconomic Change in West Africa*, J. Caldwell ed., New York and London: Columbia University Press for the Population Council, New York, pp. 565-581.
- Seaman, J., J. Rivers, J. Holt and J. Murlis (1973) An inquiry into the drought situation in Upper Volta, *The Lancet*, No. 7832 (October 6), pp. 774-778.
- Sebai, Zohair A. (1969) *The Health of the Bedouin Family in a Changing Arabia*. Ph.D. dissertation. Baltimore, Maryland: School of Hygiene and Public Health, The Johns Hopkins University.
- Shamekh, Ahmed A. (1975) *Spatial Patterns of Bedouin Settlement in al-Qasim Region Saudi Arabia*. Lexington, Ky: University of Kentucky, Department of Geography.
- Singh, J., R. L. Singh, and K. N. Singh (1971) Rajasthan, in *India: A Regional Geography*, R. L. Singh, ed., Varanasi: National Geographical Society of India, pp. 7-82.
- Smith, Susan E. (1976) Personal communication, July 14, 1976. International Division, Africa Programs, American Friends Service Committee, Philadelphia, Pennsylvania, USA.
- Splinter, William E. (1976) Center-pivot irrigation, *Scientific American*, ccxxxiv: No. 6, 90-99.
- Swift, C. R. and T. Asuni (1975) *Mental Health and Disease in Africa: With Special Reference to Africa South of the Sahara*. Edinburgh, London and New York: Churchill Livingstone.
- Talbot, Lee M. (1972) Ecological consequences of rangeland development in Masailand, East Africa, in *The Careless Technology: Ecology and International Development*, M. Taghi Farvar and John P. Milton, eds., Garden City, New York: Natural History Press, pp. 694-711.
- Tarizzo, Mario (1976) Control of trachoma, *World Health*, February-March, pp. 10-14.
- Tien, H. Yuan (1973) *China's Population Struggle: Demographic Decisions of the People's Republic, 1949-1969*. Columbus, Ohio: Ohio State University Press.
- Toupet, Charles (1975) *La sédentarisation des nomades en Mauritanie centrale sahélienne*. Doctorat d'Etat et Lettres Thesis (University of Paris VII). Dakar.
- United Nations. Educational, Scientific, and Cultural Organization. Man and the Biosphere (MAB) (1975) *Regional Meeting on the Establishment of Co-operative Programmes of Interdisciplinary Ecological Research, Training and Rangeland Management for Arid and Semi-Arid Zones of Northern Africa*. MAB Report Series No. 30. Paris: UNESCO.
- United Nations. Food and Agriculture Organization (FAO) (1975) *Report of the Consultation on Fisheries Problems in the Sahelian Zone*. CIFA Occasional Paper No. 4. Rome: Committee for Inland Fisheries, FAO.
- United States. Public Health Service. Center for Disease Control (CDC) (1973) *Nutritional Surveillance in Drought Affected Areas of West Africa (Mali, Mauritania, Niger, Upper Volta)*. Atlanta: Center for Disease Control. Mimeo.
- Walters, Stanley D. (1970) *Water for Larsa: An Old Babylonian Archive Dealing with Irrigation*. New Haven and London: Yale University Press.
- Warren, Andrew and J. K. Maizels (1976) *Ecological Change and Desertification*. Preliminary Report Prepared for the United Nations Conference on Desertification.
- West, Robert (1970) Population densities and agricultural practices in pre-Columbian Mexico, with emphasis on semi-terracing, *Verhandlungen des XXXVIII Internationalen Amerikanistenkongresses*. Munchen: Klaus Renner. Vol. 2, pp. 361-369.
- Western, David (1974) The environment and ecology of pastoralists in arid savannas. Paper read at the SSRC Symposium on the Future of Traditional "Primitive" Societies. Cambridge.
- Whitney, Joe (1976) Chungwei County, Ninghsia-Hui Autonomous Region, China, in *Profiles of Change*, Supplementary Materials to *Population, Society, and Desertification*.
- Williams, Michael (n.d.) The perception of the hazard of soil erosion in South Australia: a review. Mimeo.
- Williams, O. B. and H. Suijdendorp (1976) Draft of Gascoyne catchment: case study of desertification. Canberra, Australia: CSIRO.
- Wilson, Andrew (1976) Tucson, Arizona, U.S.A.: a case study in desertification, in *Profiles of Change*, Supplementary Materials to *Population, Society, and Desertification*.
- Wisner, B. (1976) The peasants of Tharaka Division, Meru District Kenya, in *Profiles of Change*, Supplementary Materials to *Population, Society, and Desertification*.
- Wolf Eric R. (1966) *Peasants*. New Jersey: Prentice-Hall.