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Cover: Saxaul growth in the Great Gobi National Park, Mongolia. Photo: Alain le Garsmeur

CONTENTS

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DESERTIFICATION CONTROL

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The Editor
Desertification Control
UNEP
P.O. Box 30552
Nairobi
Kenya

ENVIRONMENTAL DEGRADATION AND DEVELOPMENT OF ARID LANDS

Mark Speece,
Office of Arid Lands Studies,
University of Arizona
and
M. Justin Wilkinson,
Department of Geography,
University of Chicago

For the past two years the Office of Arid Lands Studies at the University of Arizona has been compiling handbooks on natural resource development and environmental problems in a number of developing countries, mainly in arid regions of the world. This project is sponsored jointly by the United States Committee of the UNESCO Man and the Biosphere Programme (MAB) and the United States Agency for International Development (USAID). The project represents the first stages of an attempt by USAID to integrate an environmental awareness into development planning.

A substantial proportion of development projects have had and continue to have adverse effects upon the environment, and USAID projects are no exception. It represents a major advance in the field of development activity that within the last decade such difficulties finally have been recognized, and steps are being taken to rectify them.

The handbooks, or more accurately "environmental profiles", prepared through the MAB project, are envisioned as the first part of a more thorough analysis of resource and resource management, environmental problems, and the interrelation of these with development planning. To date, environmental profiles on more than a dozen countries in the arid regions of Africa, the Middle East, and South Asia have been compiled. Natural resources of each country, particularly mineral, water, soils, vegetation, and wildlife, are surveyed; more importantly, the management and use of these resources are reviewed. Specific current and potential problems are identified to show which areas are or may become most critical in terms of environmental degradation.

The most common environmental problems found in every country profiled in the MAB project are degradation of natural vegetation cover, severe soil erosion, depletion of water supplies, and a number of environment-related health problems.

Northern Niger. Photo: J. Johnson, Office of Arid Lands Studies

A nomadic family near Agadez, Niger. Note the barren landscape. Photo: J. Johnson, Office of Arid Lands Studies

In most arid areas, expansion of agriculture depends upon the development of newly irrigated perimeters, and such projects usually lead to increased soil and water salinity. Countries with large irrigation schemes from great rivers, such as the Nile and Indus, also have to contend with waterlogging of productive soils. Overpumping of ground-water aquifers results in declining water tables, and sea-water intrusion in coastal areas. These types of physical problems, if not countered, usually lead to desertification, which in economic terms means loss of productive land and thus a decreasing productive capacity.

Physical aspects of environmental problems are covered in great detail in recent research on and discussion of desertification, including recent issues of ***Desertification Control***. By contrast, the socio-economic and institutional factors behind these problems have received much less attention. While it may be noted that overgrazing or land reclamation for agriculture are two of the major factors in depletion of vegetative cover and are thus factors in soil erosion, the tendency has been simply to blame the ignorance of the farmer or herdsman for the problem. However, farmers and herdsmen are quite often perfectly well aware of the detrimental effects of many of their actions. Traditional land-use systems were usually well adapted to fragile ecosystems and caused minimum damage to them. Very often rapid population growth and the intrusion of modern factors disrupt traditional systems, leaving the inhabitants with the choice between starvation or actions to increase food production even at the expense of degradation of the environment.

Making such choices sometimes involves institutions at the national level in many countries, to the extent that environmental degradation is, in a sense, actually planned. It is well known, for instance, that massive irrigation projects may well lead to soil salinization and waterlogging, depletion of ground-water resources, or increased incidence of certain diseases. However, the alternative of not initiating such projects and thereby courting massive food shortages is not an acceptable solution.

Such perspectives may not be readily apparent from analysis of the situation in individual countries. The trend becomes strikingly clear, however, when it is seen in nearly every country profiled. The four cases briefly reviewed here were chosen to demonstrate that similar institutional factors are behind a wide range of different desertification processes, at local, regional, and national levels.

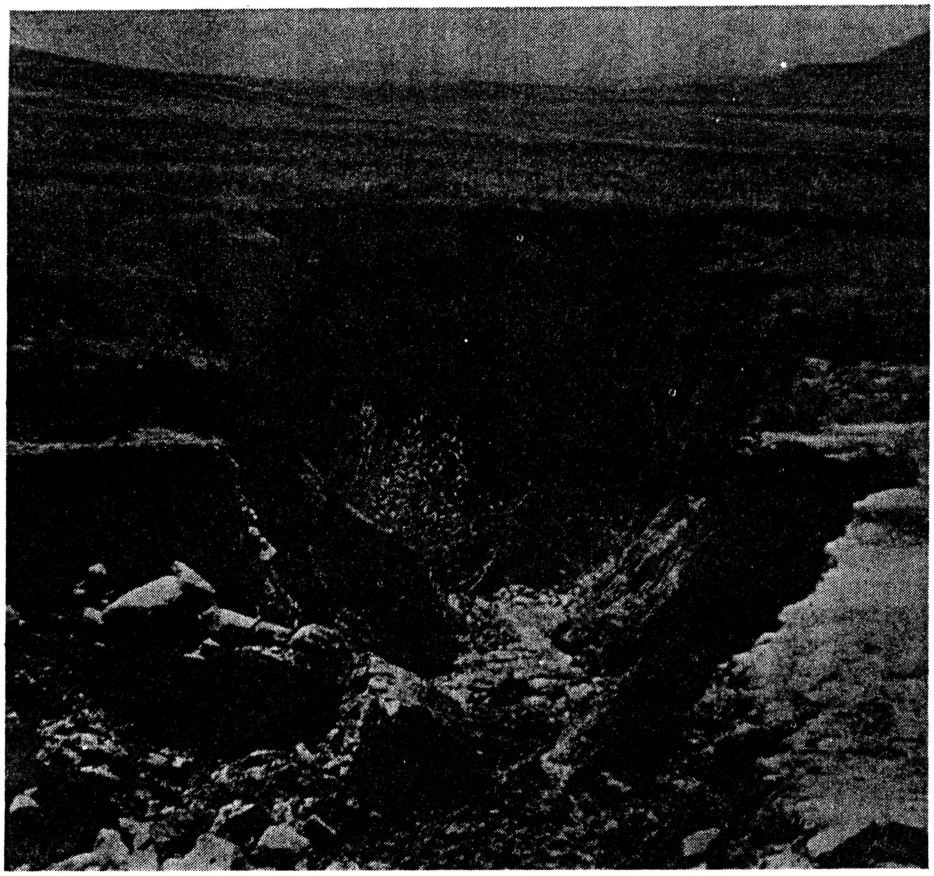
Rangeland Degradation in the West African Sahel

One of the chief causes of rangeland degradation cited in desertification literature is overgrazing. The standard explanation of the process is very familiar by now. The general outline is that pastoralists increase herd size beyond the carrying capacity of the available range resources. The animals consume forage vegetation faster than it can regenerate, and eventually inedible or no vegetation remains. With degraded ground cover, soil erosion becomes serious and any chance of restoring the range becomes remote because of massive topsoil loss.

A common variation presents nomads clustering at wells during times of drought, concentrating their herds in the areas around the wells. The range deterioration in the local areas centred on wells proceeds and these individual areas of devastation gradually expand and link up.

It is difficult to criticize this general model. The process has been examined in the Sahel and elsewhere countless times over the last several decades, and it does, in fact, usually proceed as outlined. However, the question is why the process happens. Is it really, as many have asserted, because the pastoral economy places such a high value on animal ownership that herders wish to go on accumulating animals even to the detriment of the environment? Should we believe that because most nomadic societies traditionally lack the concept of private land ownership, they think only of their own herd and do not care if the range vegetation is depleted? This kind of approach seems to be rather unproductive, a kind of "blame the victim for the crime" concept.

The most useful approach seems to be an examination of the pastoral economy over time to determine whether pastoralism has always brought about the kind of rangeland degradation which we see today. These pastoral economies have existed in the Sahel for millennia. It is not



An erosion gulley in a sorghum field, Lesotho. Photo: J. Wilkinson

likely, therefore, that the Sahel has seen throughout history the kind of serious environmental degradation which it has witnessed in the twentieth century. Historically, several of the most prosperous African kingdoms, including Ghana, Mali, and Songhay, arose in the Sahel. Their economies were based on long-distance trade, agriculture, and pastoralism, each sector mutually interdependent.

More importantly, agriculture and pastoralism were in balance with ecological conditions; rangeland degradation seems only to have been a problem at a few specific times. It is intriguing that these times are precisely those periods of chaos during which one state collapses eventually to be replaced by a successor. In other words, these periods of critical ecological degradation coincide with periods of severe social and economic disruption.

The current ecological problems in the Sahel can also be viewed as occurring during one of these periods of severe economic upheaval. The Sahel throughout the twentieth century has witnessed the gradual disintegration of its traditional trade, subsistence agriculture, and pastoral economy under the impact of the world market economy. As the cash economy penetrated, farmers had to shift to cash crops in order to raise the necessary money to pay taxes or to buy what they formerly obtained through barter. In many cases cash cropping, particularly in the case of peanuts, was imposed by the colonial regime to meet outside needs. To increase cash income, and to maintain food production levels, farmers were forced to expand cultivation into marginal areas, even though they usually knew quite well that these areas were not well suited in the long run to cultivation. Such expansion brought ecological degradation, but failure to expand meant less food to feed the family and less cash to provide other family needs. To farmers living at the subsistence level, this extra cash or food often translated into the difference betwen survival or starvation.

Pastoral nomads also lived at a subsistence level, and the necessity of paying taxes and buying supplies in cash meant expansion for them also. Expansion to the pastoralist, of course, translated into increased herd size. This in itself would have upset the delicate balance between herding and the environment, but changes in other traditional sectors also had direct impacts on pastoralists. With trade increasingly monopolized by Europeans, even the meagre incomes derived from the caravan trade were cut off. With crop production converting to cash crops for the European market, fodder prices inflated rapidly. Such factors increased the need to expand herd size. At the same time, agriculture expanded into the areas where the nomad used to pasture his animals, and he, too, had to move his larger herd to areas which were more arid and less suited to grazing.

Sometimes wells would be drilled in the more arid regions to provide drinking water for livestock. Of course, the nomads began to concentrate their herds around such wells, bringing even more rapid range deterioration in local areas. Planners began to wring their hands and wonder about the irresponsibility of the pastoralists. Should anyone, however, have expected the nomad to take his herd off into the desert to die of thirst?

The traditional herder is not the culprit. He knows perfectly well that the areas he has been forced into cannot sustain large numbers of animals in the long run. That is why he was not normally found in these areas until forced out of zones where pastoralism was economically and ecologically sustainable.

Soil Erosion in Lesotho

Some of the worst soil erosion problems in southern Africa are encountered in Lesotho, a small landlocked country of 1.2 million people surrounded on all sides by South Africa. The eastern portion of the country consists of high mountain ranges, reaching over 3,000 m in places. Although the eastern escarpment may receive up to 2,000 mm of rainfall annually, the intermontane valleys are comparatively dry and most of Lesotho falls within the sub-humid and semi-arid zones. The major population centres are in the western lowlands, an area of around 700 mm annual rainfall and prone to drought.

The basis for Lesotho's current status can be traced back to 1868, when the nation's first leader sought and obtained British protection against the encroachment of white

settlers to the west. As a result, Europeans were never welcome in the country and traditional land tenure systems remained fairly intact. Land ownership is vested in the king and is held in trust for the Basotho, who are primarily a pastoral and agricultural people. Chiefs and subchiefs allocate agricultural land, traditionally designating three fields to each household head. Communal pasture-land is open to all.

When Lesotho became a British protectorate, however, it was forced to cede the western half of the traditional Basotho homeland to European settlers. (The west bank of the Caledon River is now termed "the conquered territory" by the Basotho.) This was the beginning of a long-term trend experienced in much of Africa. As colonialism and European settlement became established, land shortages became acute for the traditional shifting agriculture and pastoralism of the country. On the remaining land, a vicious cycle was set in motion: overpopulation, intensification of land use, and progressive loss of soil productivity. The land was less and less able to support the increasing pressure on it, and masses of Basotho were forced into migrant labour, supplying the growing industries and mines of South Africa.

One result of the forced cession of territory west of Caledon was the migration of many Basotho to the remaining areas of Lesotho. By the 1880s population pressures in the western lowlands of the country were mounting, and people were forced to seek land in the previously very sparsely populated highlands, particularly the Orange River Valley. South African laws in 1912 and after 1950 which aimed at repatriating Basotho remaining in European areas, only added to Lesotho's population problems.

By the mid 1970s, Lesotho's population density was 59/sq km, far above densities in surrounding areas (South Africa: 33/sq km). Only about 3 per cent of the population was urban, so the vast majority of Basotho are still in the rural sectors (although not all work in agriculture; some migrate for employment to South Africa). In recent years Lesotho has experienced high unemployment rates as there is no longer available land to support the population in agriculture or pastoralism. Approximately 10 per cent of all Basotho households have no arable land at all, and the average number of fields per household of landholders is down to 2.3 from the traditional 3.

Soil and pasture productivity has continued to fall as a result of this intensification of use. Already in the 1930s one survey estimated that the carrying capacity of the country's natural pastures had been reduced to half of what it was formerly. In agriculture, fallow periods have been reduced or eliminated, monoculture cultivation has increased, and the use of dung as fertilizer has declined as fuel needs increased. New fields have had to be created to replace those whose soil had been exhausted. The only areas now available for new fields are on lands which are steep and highly prone to erosion.

Lesotho has declared the creation of such new fields illegal. However, enforcement is nearly impossible and the process continues, exacerbating the country's erosion problems. Nearly half of all cultivated areas suffer erosion, and about 12 per cent show severe erosion. It is estimated that sheet erosion causes the loss of 70 metric tons of top soil annually per hectare of arable land. Gully erosion has already caused the permanent loss of 4 per cent of Lesotho's cultivated land, and the country is losing an additional one per cent every four years to new gullies or the widening of old ones. This translates into a loss of about 1,000 hectares each year. The cycle of reduced productivity, the addition of new fields and increased erosion has resulted in the total cultivated acreage in Lesotho remaining relatively constant.

Aerial view of the Drakensberg Mountains showing the scars of soil erosion.
Photo: T. Fincher, WFP

Pasture lands have also suffered. Normal carrying capacities would require about 4 million hectares of rangeland for Lesotho's 500,000 cattle, 1.2 million sheep and 600,000 goats. Unfortunately, the country has only about one million hectares of grazing land available. This overstocking has resulted in severe depletion of vegetative cover throughout much of Lesotho, and invasion of many areas by semi-arid land shrubs from the Karroo Desert to the southwest. These shrubs are of little use for grazing, and furthermore, do little to bind soil in countering erosion.

A related phenomenon, found exclusively in the highlands, is the desiccation and erosion of peat bogs which occupy valley heads in the major ranges. These brilliant green bogs act as convenient watering places for livestock and therefore have suffered excessive trampling. The resulting compaction caused the bogs to dry out and they became prone to deflation by high winds. The reservoir capacity of these "sponges" is greatly reduced, and downstream areas are subjected to more intense flood peaks, lower dry-season flows, and increased silt loads in stream flow, all of which aggravate problems already occurring.

Lesotho, then, was forced into its present position partly by the direct application of outside political power over the last century. The farmers and herders did not choose to be crowded into a small country where they would have nowhere to go except onto steep, easily erodible, inhospitable mountains.

Local Agricultural Development and Desertification in Southern Arabia

Physical conditions in the Yemen Arab Republic (YAR) and the Sultanate of Oman have given rise to a wide variety of agricultural organizations. In the YAR, traditional systems in the Tihama coastal plain are based upon spate irrigation which diverts flood flow in the wadis traversing the coastal plain. These floods normally come only a few times a year at best, during the rainy season. Flood flow is captured by means of an elaborate network of weirs and barrages and directed by canals to fields lying along the wadi course.

In the highlands, the most distinctive feature of Yemeni agriculture has traditionally been the terrace. They comprise numerous, small, hand-constructed plots of flat land on steep mountain slopes. Terraces trap rainfall, and receive and retain runoff from upslope areas. They may be cultivated or used for grazing. In either case terraces allow production in Yemen's arid highlands which would otherwise go unused.

While the two major agricultural systems of the YAR are based upon the capture of surface runoff, traditional agriculture in Oman utilizes ground water. Again in Oman there are two main types of irrigation. In the Batinah coastal plain, shallow hand-dug wells are the primary source of irrigation. Draft animals draw water

The water table is so near the surface at Mohenio Daro that capillary action carries water up into the bricks of the ancient site, and evaporation leaves behind salt. Photo: M. Mahar, Dept. of Oriental Studies, Univ. of Arizona

by means of a hoist and bucket, and the water is dumped into a basin and channeled to fields or gardens.

In the interior of the country most irrigation water is obtained by means of a *falaj* (plural *aflaj*). One kind, called the *ghayl falaj,* uses a low bund or a short collector gallery to divert the perennial flow below the gravel surface of a wadi. Water is channeled to terraced or cleared fields along the wadi. The second kind, called a *qanat falaj,* is also known under a variety of names in other regions from North Africa to western China. It consists of horizontal tunnels dug into alluvial fans to tap the water table. A vertical shaft is sunk first to verify the existence of a suitable shallow aquifer, then the tunnel is excavated. Additional vertical shafts are used for ventilation, cleansing and maintenance.

These widely differing systems in Yemen and Oman have in common the fact that they are quite compatible with the arid conditions under which they have evolved. Spate systems, for example, utilize only flood water which would otherwise flow into the sea. Construction of a terrace system prevents soil erosion, and by trapping runoff, allows more water to infiltrate to water tables. Water is not extracted from the shallow wells of the Batinah rapidly enough to deplete water tables. *Aflaj* tap only renewable shallow aquifers for high quality water.

The systems also have the common feature that all are fairly labour intensive. In recent decades both Yemen and Oman have seen massive migration out of rural areas. Not surprisingly, the traditional labour-intensive systems have begun to break down. Diversion systems are not maintained and are eventually washed out or clogged. Terraces deteriorate and can no longer prevent soil erosion. Eventually entire hillsides are stripped of any productive capacity. This leads to increased flooding and sedimentation downstream, which reinforces the decline there. The flow of *aflaj* declines as they deteriorate, and land irrigated by them goes out of production.

The introduction of labour-saving technology may only compound the problem. For example, tractors are imported, and these damage field-containing walls. The worst offender, however, is the modern water pump.

Building a main drainage canal along the banks of the Nile within view of the Valley of the Kings, Egypt. Part of an irrigation system financed by the World Food Programme. Photo: FAO–WFP

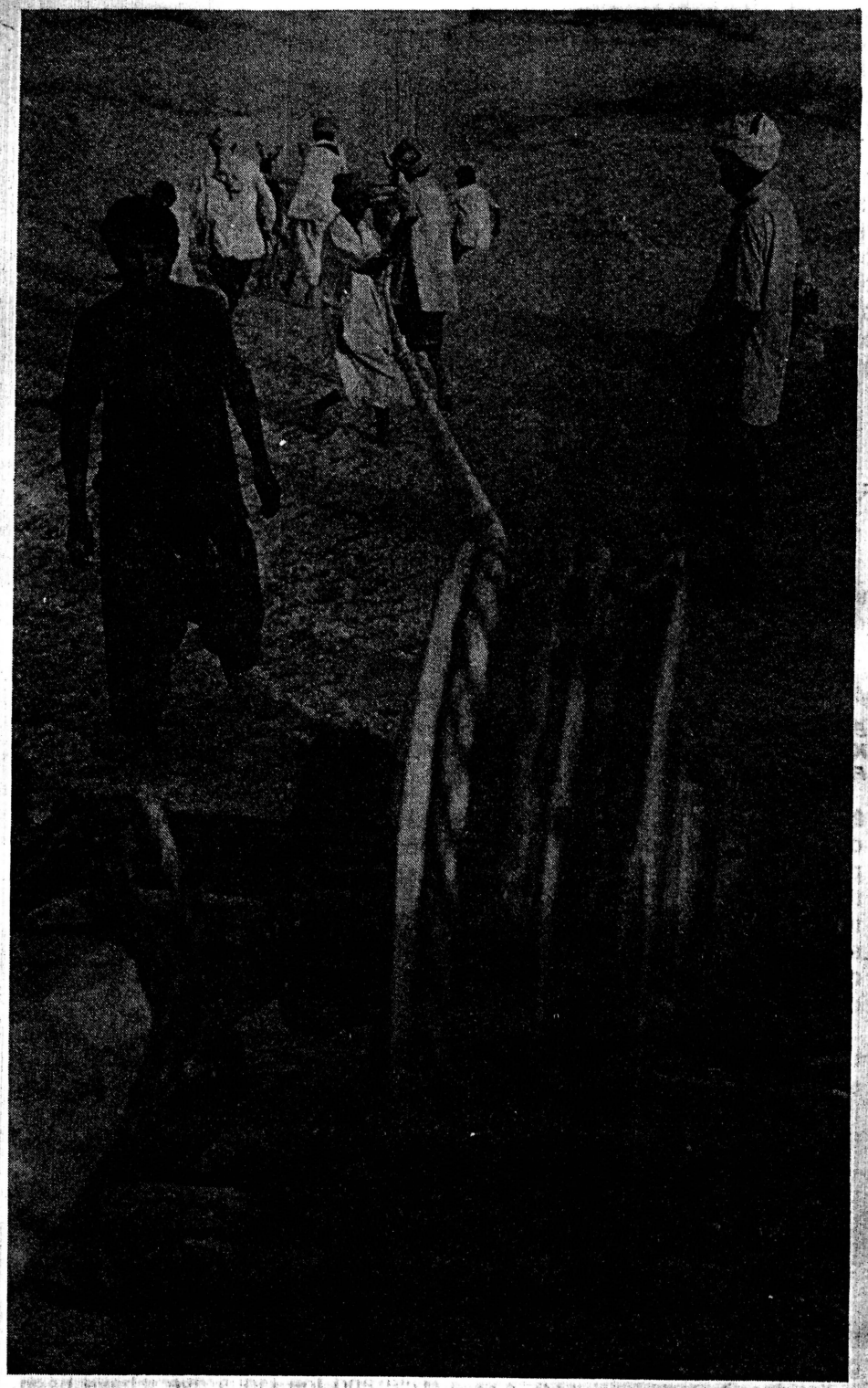
Neither Yemen nor Oman has any comprehensive regulation on water pumps, and the result is that water tables drop rapidly. In interior Oman, this leads to the failure of many *aflaj,* so that even more pumps are required. In the coastal plains of both countries, this has led to sea-water intrusion of coastal aquifers. The aquifer becomes polluted with salt water, soils become salinized, the land loses its capacity for agricultural production, and the desert moves in. Along the Batinah coast in Oman, for example, date palm groves are dying because of salinized water, even though the date palm is a relatively salt tolerant tree.

We might blame the ignorance or the selfishness of the farmer who goes off to work and leaves his land to the desert. Can we really fault him, however, for wanting a share of the benefits of modernization along with the rest of the world? Should we blame farmers who use pumps? It is well known that pumps induce problems with water quality and declining water tables. Without a pump, however, farmers often cannot irrigate at all because the traditional irrigation systems no longer function.

These dilemmas have reached the national level. Oman, for example, usually subsidizes pump purchases, and well-drilling projects are a major part of most government agricultural schemes. Descriptions of planned projects even include the acknowledgement that sea-water intrusion or dried up *aflaj* will result. The government is well aware that such policies pose long-term threats to the environment, but short-term problems require a response, and the international community has not yet come up with any better solutions.

Large-Scale River Irrigation Projects : Egypt and Pakistan

In both Egypt and Pakistan the dilemmas which we have noted can be examined best at the national level. Large-scale irrigation projects on the Nile and the Indus rivers have been the basis of agricultural development in these two countries. The key to desert reclamation schemes in Egypt was the Aswan High Dam which was put in use in 1960. By 1981, the dam had enabled Egypt to add over 1.2. million feddans (1 feddan = 0.46 hectare) to its cultivated area. It also allowed for conversion to perennial irrigation, which means that fields can be cropped two or even three times annually. These increases have re-



A pulley system is used to lift water in a goatskin bag from a well, 340 ft. deep, at Gadro. This single well must supply a population of some 6,000 persons. Photo: G. Di Majo, WFP

sulted in modest overall increases in Egypt's agricultural production, but per capita production has actually dropped.

Ironically, despite significant acreage increases, losses of a comparable order have come about as a by-product of the reclamation schemes. Extensive soil waterlogging and salinization have been a direct result of these massive irrigation schemes in Egypt. Fully 28 per cent of the country's agriculturally productive land has been affected to some degree. Average yields in affected areas have decreased an estimated 30 per cent, and some lands have been abandoned. In the region of Kom Ombo in Upper Egypt, for example, the ratio of new land irrigated to land lost to production is approximately 1:1.

Waterlogging and salinization occur because more frequent irrigation and extension of the canal network allows vastly increased seepage from canals as well as increased infiltration from fields. Water tables rise close to the surface of the land where they are constantly subject to evaporation. The result in waterlogged soils is salt buildup.

The Egyptian response in recent years has been directed towards sealing canals to prevent seepage and installing drainage tiles below field surfaces to facilitate drainage. These programmes are quite expensive and have required massive outside financing. The environmental problems which accompanied the Aswan Dam and subsequent irrigation development were actually predicted by many before the dam was ever built and a few suggested beforehand that the kinds of tiling programmes now being implemented should have been part of the irrigation expansion programme from the start. The predictions were borne out in the areas first reclaimed but irrigation expansion nevertheless went forward.

Many among the international community were quick in pointing out to Egypt the apparent folly of its actions. It would be more profitable, however, to examine the question of why Egypt undertook an agricultural programme when it had warning that environmental deterioration would be a significant negative result. Some have suggested that although the warnings had been offered, few people actually expected the problems ever to reach the present magnitude. It must, however, be pointed out that such consideration may have been almost irrelevant given the socio-economic context of the 1950s. Egypt was faced with a rapidly growing population. Agricultural output had to be increased if famine was to be avoided in the near future.

Egypt already had one of the highest yield ratios per unit land in the world, and therefore there were very limited prospects for increasing production through improvement of cropping methods. The only way to substantially increase production was to

expand the cropped area and crop more than once annually. For this, expansion of irrigation was necessary. The 1950s was also a period when Egypt's access to major funding sources was severely restricted. In essence, the government was left with only one realistic option: to proceed with limited funding, which would not allow for expensive environmental protection measures.

Pakistan is facing problems similar to those in Egypt. Development of the Indus and its tributaries for irrigation has been a primary factor in the country's agricultural development. It is estimated that nearly half of Pakistan's irrigated land is affected to some degree by waterlogging and/or salinization; in Sind Province the figure reaches over 98 per cent. Just as in Egypt, the government must continue to expand irrigation in order to keep pace with population growth, and so far, per capita agricultural production has just kept pace. Irrigation programmes continue with the full knowledge that waterlogging and salinization will result. In fact, nearly 40 per cent of the funds for water development in the Fifth Five Year Plan (1978-1983) are allocated to drainage and reclamation of waterlogged and salinized land, while irrigation receives just over 25 per cent of these funds. Over 100,000 tube wells have been installed since the early 1960s in an effort to pump out ground water rapidly enough to lower water tables. Just as in Egypt, it is doubtful that any other options are open to Pakistan. To cut back on irrigation expansion would mean that agricultural production would rapidly fall behind population growth.

Conclusion

These four brief examples do not by any means exhaust discussion of the socio-economic and institutional factors behind environmental degradation. The problems of firewood gathering, for example, could be added to illustrate the problem. Deforestation is a major contributing factor to desertification. Those who must gather wood for fuel know about deforestation; they know better than any that it becomes more difficult to find wood every year. But can planners realistically expect those dependent on wood for fuel to give up cooking their food or heating their houses in the interest of environmental protection?

We have chosen these examples because they illustrate that behind many very different causes of desertification lie exactly the same kinds of choice. Pastoralists, farmers, or government officials are usually aware that their actions are not the best possible solution to problems which they face and that they may, in fact, contribute to environmental degradation. Planners must recognize this point, and the world community must recognize that a great many of the socio-economic problems contributing to the desertification process will not be solved at the local or even national level. They are international in scope. We cannot ask a Sahelian nomad to pasture his flock more rationally. Within the options the world has imposed on him, he is already acting in the most rational manner possible.

The physical problems of environmental degradation and resulting desertification are well known and well researched. From a purely technical point of view nearly all these problems can be solved. The major focus, however, must shift away from action exclusively on the technical level. It is already increasingly recognized that behind nearly every environmental problem lies some socio-economic or institutional dynamic which must be addressed if there is to be any hope of lasting solutions. Many have already realized that desertification itself is not a local or national problem but a global one. The world must also recognize that the factors behind desertification are likewise international in scope.

NOTE

The list of countries profiled in this project includes the following: Cape Verde (1980); Egypt (1980); Gambia (1980); Lesotho (forthcoming); Mali (1980); Morocco (1980, revised 1981); Niger (1980); Oman (1981); Pakistan (1981); Senegal (1980); Sudan (forthcoming). Tunisia (1980, revised 1982); Upper Volta (1980); Yemen Arab Republic (1980, revised 1982); Zambia (1982); Zimbabwe (forthcoming).

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