DESERTIFICATION CONTROL: A FRAMEWORK FOR ACTION

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Abstract. Desertification is a little-understood term that aggregates several land degradation processes occurring in the arid regions of the world. The major processes are vegetation degradation, water erosion, wind erosion, salinization, and soil compaction. Water erosion is the principal threat to environmental stability in both arid and humid climatic zones. Land degradation is generally reversible unless damage is very severe or soils are shallow. Practices to control land degradation are widely available but are not put to use for many reasons. Absence of a food crisis in developed countries is one of the important reasons. A related reason is the perception that no real problem exists. A third reason is that degradation control is not cost effective, except for controlling salinity and compaction. It is time to change emphasis from reducing on-site damage to reducing off-site damage.

1. Introduction

Desertification is the result of a complicated interplay of social, economic, and technical factors. Desertification control is a fairly straightforward procedure, technically, but one that commonly is difficult to carry out. The difficulties sometimes arise because of the variability of climate and other physical factors or because of a lack of political will. But the most important factors are economic and social. My framework for desertification control is based primarily on the ease with which control can be accomplished and the economic benefits of repairing land degradation damage.

Before pursuing the matter of desertification control, we need to understand what is meant by desertification. As used here, desertification is land degradation in the drylands due largely to human activities. Degradation refers to a reduction in the biological potential. The principal desertification processes are vegetation degradation, water erosion, wind erosion, salinization, and soil compaction (Table I). My global estimate of desertification according to land use is that approximately three-quarters of the world's rangelands are at least moderately degraded, as are about half of the rainfed cropland and around one-quarter of the irrigated land (Dregne and Chou, 1992). Only about 0.01 percent of the drylands are estimated to be very severely (irreparably) desertified.

2. Potential for Land Reclamation

Desertification control can mean restoring degraded land to its original productivity or only stopping further degradation. The difference depends upon the objectives

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TABLE I

Criteria for desertification class

Desertification class potential	Plant cover	Water erosion	Wind erosion	Salinization	Soil compaction	Productivity % of	
						Rangeland	Cropland
Slight 90–100	Excellent range condition	None to little	None to little	$EC_e \times 10^3 < 4$dS/m	None to little	75	100
Moderate 75–90	Good range condition	Moderate sheet and rill erosion, few shallow gullies	Soil deposits in furrows and along roads, uneven road surface	$EC_e \times 10^3 < 4$–8 dS/m	Reduced water penetration thin plow plan	50	75
Severe 50–75		Severe sheet and rill erosion, gullies common	Sand blasting of plants, soil accumulation in fencerows and furrows, blowouts and hummocks common	$EC_e \times 10^3$ 8–15 dS/m	Restricted water and root penetration, thick plow pan	25	50
Very severe 0–50	Poor range condition	Soils very shallow over parent material, many deep gullies	Calcrete exposed, dune formation, many blowouts and hummocks soils	Thick salt crust, nearly impermeable	Thick and hard plow pan	0	25

TABLE II

Potential for economically reversible land restoration[a]

Desertification process	Desertification class			
	Slight	Moderate	Severe	Very severe
Vegetation degradation, rangeland	High	High to low[b]	Low to very low[b]	Very low
Water erosion	High	Medium	Very low	Very low
Wind erosion	High	Medium	Low	Very low
Salinization	High	High	Medium	Low
Soil compaction	High	High	Medium	Low

[a] Restoring land to approximately its original productivity.
[b] Depends heavily on climate.

of the reclamation project and on the degradation processes (Table II). Salinized and compacted soils can be restored to something like their original condition in nearly every case. Vegetation degradation can be fully compensated, in principle, unless the soil also has been degraded. In practice, however, vegetation restoration of rangelands where the average annual precipitation is less than about 150 to 200 mm may be so slow as to be economically impractical.

The main reason is climate variability. If shrub increase or invasion is extensive, restoration of a perennial grass cover may well be impossible in a human lifetime unless an expensive, long-lasting improvement project is undertaken, even if the annual precipitation amounts to as much as 350 to 400 mm.

Wind erosion damage to soil is reversible if the soil is uniform and deep and if the soil surface can be smoothed to eliminate ridges and hummocks. The damage becomes economically irreversible on rangelands when blowouts (hummocks interspersed with depressions scoured by wind) have formed. Long-term wind damage to cropland usually consists of sand deposits from locally eroded fields and scouring that exposes unproductive subsoil layers. Both forms of damage may occur in the same field.

Water erosion is the most damaging land degradation process. Soil loss, whether due to sheet, rill, or gully erosion, is a degrading process whenever the rate of loss exceeds the rate of new soil formation. Since soil formation is mostly a process that forms new soil at rates of a centimeter in several decades or centuries, even low erosion rates of a few tons per hectare per year are soil degrading. Deep soils free of root-inhibiting layers, such as the aeolian deposits on the Loess Plateau of China, may remain highly productive after many years of severe sheet and rill erosion. Gullies cause immediate and easily observable reductions in productivity. Rills (very shallow gullies) also are readily visible, but sheet erosion does not leave an obvious trace of its occurrence. Sheet erosion may go on for years, attracting attention only when soil is deposited on roads or the tops of hills become lighter

in color. By the time the knobs of hills change color, permanent losses of soil productivity will have occurred. All that erosion control can do in that case is to stop further productivity losses. While the eroded soil cannot be returned to its exact original condition, the soil can often be restored to its original productivity level, given good management.

3. Land Reclamation Priorities

There is no likelihood in the foreseeable future that governments, donor agencies, or land managers are going to stop and reverse desertification on the 3.5 billion ha of degraded drylands. The cost simply is too high. Furthermore, exaggerated claims about the extent of food shortages that land degradation will cause have dulled responses to a very real threat. Land degradation is an insidious process that can easily be ignored over the short term.

The United States would probably not have an effective and broadly supported soil conservation program if Hugh Hammond Bennett had not been a superb publicist as well as a good scientist. He was helped tremendously by the 1930s depression and the Dust Bowl black blizzards. A story that may or may not be correct says that dust fallout in Washington, D.C. from a west Texas storm persuaded Congress to establish the Soil Conservation Service in 1935. A thick layer of dust in offices and homes and on automobiles made a greater impression than endless statistics on soil and crop damage in the Great Plains.

3.1. Setting Priorities

Table II, indirectly, is a priority list for land reclamation if restoring productivity is the paramount concern. Highest priority would be given to salinity control and reducing soil compaction on croplands. These are the easiest measures to take, and the yield response is fast. Preventing further degradation by erosion, overgrazing, and woodcutting is best undertaken when the damage is moderate.

A priority list would be different if off-site damage were the primary consideration. Water and wind erosion are the only degradation processes that generate significant off-site damages. Salinization of irrigated land can sometimes degrade downstream water quality, but the effect is not globally extensive.

3.2. Off-Site and On-Site Effects

Off-site water erosion impacts are related to increased runoff from eroded land and the deposition of eroded particles at lower elevations (Clark, 1985). Increased runoff leads to greater flooding downstream as well as to sediment deposition on adjoining fields and on highways, urban areas, and floodplains and in rivers, lakes, and reservoirs. Runoff from farm fields carries nutrients in solution and on

TABLE III

Percent of degraded agricultural land capable of providing net economic benefit from reclamation*

Land use	Percent
Irrigated land	98
Rainfed cropland	70
Rangeland	30

*At least moderately desertified.

soil particles. The nutrients can pollute water supplies. By comparison, the on-site detrimental effect of water erosion is principally to reduce soil productivity.

Off-site wind erosion impacts are many and varied (Huszar and Piper, 1986). They include damage to (1) human and livestock health from air pollution; (2) crops, machinery, and exposed surfaces from sand blasting; (3) highways, railroads, water bodies, fields, and landscaped areas from the deposition of saltating particles and surface creep; and (4) air and automobile traffic from suspended particles that severely reduce visibility. Detrimental on-site effects mainly consist of sand blasting and burial of crops, unevening of field surfaces, reduction in soil fertility, and, sometimes a reduction in long-term soil productivity (Davis and Condra, 1989).

3.3. RECLAMATION BENEFITS

My own estimate of the developmental priority for desertified land is shown in Table III, but a strong element of opinion enters the calculation. My evaluation of published economic studies and comments by colleagues in other countries leads me to believe that the 98 percent figure for irrigated land is reasonably accurate. This figure is high because returns from irrigated drylands can be high if good management is practiced. Failure of large irrigation projects is legendary, but not because the potential land productivity is overrated. That is demonstrated by the high productivity of small plots of land irrigated by shadufs or individual pumps. Management is the key.

Rainfed cropland reclamation is less certain of being profitable. There is a consensus that soil conservation projects usually are not profitable in the short term of 5 to 10 years insofar as onsite benefits are concerned. These projects may, however, have a positive benefit/cost ratio over the long term.

Dryland projects that combine soil conservation with yield-improving water conservation are the exception. Such projects can increase yields immediately. Reducing the off-site impacts of erosion, particularly flooding and soil deposition

on highways, these projects are probably profitable in certain places. But they benefit a broad base of taxpayers instead of identified beneficiaries.

The economic benefits of rangeland improvement become more speculative as the climate becomes drier. There is no question about that. There has been mounting pressure on the world's better grasslands for centuries. During relatively wet periods, grasslands are plowed and converted to rainfed croplands. Sometimes these lands are abandoned when the inevitable droughts recur, but these lands are usually not abandoned or are cropped again when another wet period comes along. The consequence of this global land use change is that rangeland area is reduced in the favorable regions and expanded in the less favorable regions, making degradation control even more speculative.

4. Land Degradation Control Problems

A distressing aspect of action programs to control land degradation is the record of the U.S. soil conservation agencies. A 1983 analysis of the effectiveness of the U.S. conservation program concluded that after 50 years and an expenditure of $18 billion, soil erosion remained "a formidable problem" (General Accounting Office, 1983).

On the other hand, virtually instant success followed the introduction of the 1985 Conservation Reserve Program (CRP). Within 4 years of beginning the CRP, erosion was estimated to have declined by about one-third. The decline was the result of returning highly erodible cropland to native vegetation and the requirement for having conservation plans on farms receiving federal support payments (Weber, 1990).

The 1950s Soil Bank program also retired cropland from cultivation. It, too, had an immediate impact. Unfortunately, former grasslands were plowed up again after the 10-year program ended (Wight *et al.*, 1983). That will also occur after 1995 if financing for land retirement under the CRP ends as scheduled. The cross-compliance requirement, if continued, will partially offset the end of land retirement.

The CRP experience demonstrated clearly that if a nation has the political will to control erosion and has the required financial resources, it can stop erosion immediately. In this case, government payments to farmers to take cropland out of cultivation were attractive. Only the most highly erodible land was targeted for conversion to grass and forest land. The targeted land was the source of a disproportionately large amount of the nation's erosion. It also was some of the least productive land, and farmers were amenable to taking it out of cultivation at a fairly low cost. Reducing erosion on the more productive land where obvious erosion is less apparent may be more difficult.

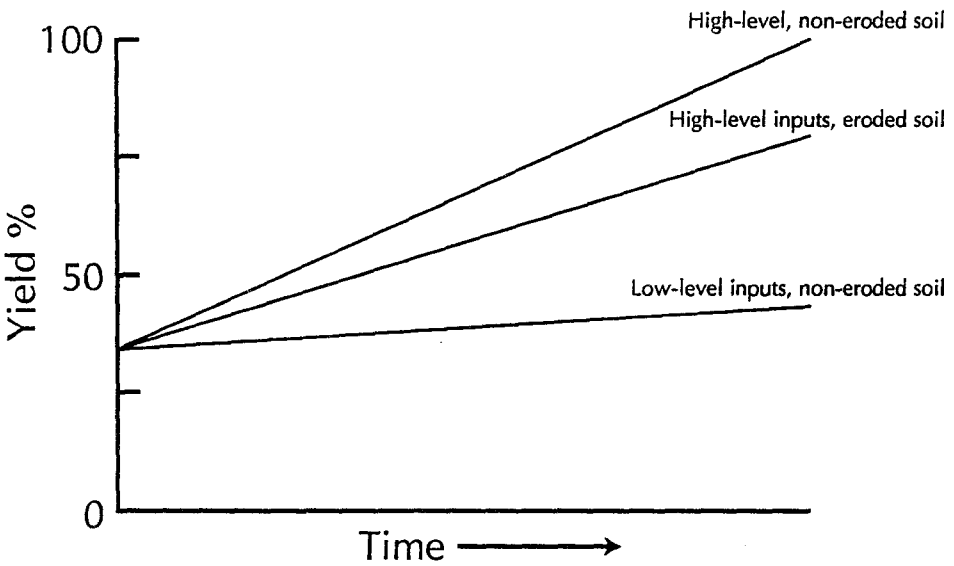

Fig. 1. Hypothetical relation of crop yields to erosion and inputs.

Erosion is only one of the land degradation processes. Fortunately, well-known practices can also control the other processes, although these practices are not as striking in their impact as changing cultivated land into grassland.

Given that desertification control practices are known, why is land degradation such an apparently intractable problem? Many reasons have been proposed. Poverty is the one that is cited over and over again by nontechnical people, in keeping with the contention that desertification is a socioeconomic problem, not a technical problem. Other socioeconomic constraints may be price controls, tenancy arrangements, belief that there is no problem or that the problem is not important now, lack of a conservation ethic, prestige associated with ownership of large herds of livestock, suspicion of governments, greater investment potential of livestock, concern for day-to-day family survival, unavailability of loans to finance conservation practices, reduction in income during first years of reclamation, negative short-term benefit/cost ratios of conservation practices, perceived excessive risk of failure to maintain family well-being, government disincentives for conservation, and lack of management skills.

There are valid technical reasons for the unwillingness of land operators to initiate land degradation control. One is the absence of proven techniques that increase productivity while improving the land. Another is the lack of advisors familiar with the recommended practices. A third is the insufficiency of proof that yields are declining, particularly where technology brings yield increases even as degradation is destroying the resource base (Figure 1).

Poverty may be the reason for mismanagement of some lands, but it certainly is not the sole reason. If it were, there would be little or no land degradation in

Australia, Canada, and the United States. Those three relatively wealthy countries have conducted national surveys clearly demonstrating that land degradation is continuing despite the money governments have spent, the availability of proven practices, and a competent advisory service.

A study of farmer perception of erosion on their farms in the Palouse region of the U.S. Pacific Northwest gave dismaying results (Osterman and Hicks, 1988). Farmers reported that water erosion was not significant even though it was readily observable during interviews. Farmers have no incentive to halt erosion that they do not believe is occurring.

Government policies sometimes encourage erosion. A prime example is the U.S. Department of Agriculture's urging of farmers to put every available hectare of land into food crop production in the mid-1970s. The incentive for that drastic change in farm policy was the shortage of wheat in the Soviet Union and the subsequent high world prices (Sachs, 1994). Conservation lost its attraction when the opportunity to reap economic benefits by disregarding erosion hazards came along.

5. Framework for Action

Recent years have seen an outpouring of concern about environmental degradation, including land degradation. An International Convention to Combat Desertification was adopted in 1994. Its objective is to combat desertification and mitigate drought impacts. Africa is the primary focus of the Convention, but all countries experiencing desertification or drought are to participate. As one reads the preparatory documents, however, it is obvious that developing countries want the Convention to help their economic development more than to combat degradation. Whether the Convention should attach economic development to desertification is a contentious issue between developed and developing countries.

5.1. Land Intensification

My proposed framework for combatting desertification is oriented toward enhancement of the agricultural productivity of a country's best land. The proposed action applies to soil erosion and rangeland degradation, not to salinization and soil compaction. Salinization and compaction are relatively easy and economic to control. My premise is that the preferred, if not only, way to reduce pressure on degrading marginal lands is to reduce the need for products of those lands.

Known techniques can be employed to intensify crop and livestock production on lands that are more favorably endowed with potentially highly productive land. A well-conceived program of land intensification will not usually be an overnight success. The proposed production methods must be tested on farm fields, if that has not already been done, and adapted to specific site needs. In addition, a support

infrastructure will be required to make available technical assistance, roads, fertilizers, and other contributors to development. An effective organization is called for to strengthen agricultural research and extension.

Agricultural policies, also, must contribute to a betterment of production, not hinder it. Simply allowing the profit motive to operate can rapidly increase crop yields. Price controls are not compatible with productivity increases. The International Food Policy Research Institute (IFPRI) has come to believe that intensification is the route to follow (Pinstrup-Andersen and Pandya-Lorch, 1994).

Along with intensification of crop production on better lands goes the need for governments to set priorities on spending resources for both increasing production (Mellor *et al.*, 1987) and controlling land degradation. As noted previously, few governments are in a position to make a broad-scale attack on land degradation. Such an attack would be too expensive, unlikely to be successful in the short term, and excessively demanding on planners and managers. It would also require knowledge that is presently unavailable.

Setting priorities at both the political and technical level is not easy. Yet priorities must be set if resources are not to be frittered away on an uncoordinated attack that would be wasteful. High on the list of essential actions is selection of the lands that would receive the first attention. One reason for choosing better lands initially is to provide the early success that would generate continued support. After the relatively easy success has been achieved, the more difficult environments can be attacked.

Economic development should accompany land reclamation so that the poverty factor in the occurrence of land degradation can be minimized. Agriculture, in all its aspects (production, marketing, research, extension, agribusiness, transportation, credit, etc.), must be the driving force for development in the near future, at least for most developing countries. High levels of crop production are fully compatible with sustainable agriculture if good management is practiced. Lands with marginal climates, soils, and slopes are the ones for which it is difficult to devise a sustainable and economically profitable cropping or pastoral system.

In western Europe and the southeastern United States crop production has been shifted to the most stable landscapes where the land degradation threat is minimal. The advent of big machinery and the ability to drain and crop low-lying level lands has brought about abandonment of cultivated land on highly erodible sloping lands. The badly eroded cotton soils in the Piedmont region of the U.S. South that helped Hugh Hammond Bennett generate support for establishing the Soil Erosion Service in 1933 are now covered with trees (Trimble, 1974). Hidden by the trees are enormous gullies and severely eroded soils.

Intensive cultivation has shifted to the low-lying soils that were formerly too wet and too heavy to farm. A similar shift occurred in western Europe, allowing sloping land to be used for pastures and woods, with a consequent drastic reduction in erosion. Productivity is so high now in western Europe that the European

Community is trying to find alternative uses for abandoned croplands (Carruthers, 1986). This concern is with too much production, not too little.

5.2. GOVERNMENT ACTIONS

To facilitate sustainable agricultural development governments can take many actions that will reduce pressures on marginal lands and improve degraded land. Actions will differ in industrialized societies and the poor less-developed countries.

Wealthy industrialized countries have the luxury of being able to finance conservation of natural resources for future generations. It is wise for them to continue to do so, although with a different focus. The new focus should be on reducing the off-site damage that pollutes water and air resources, threatens lives and property by flooding, reduces biological diversity, harms terrestrial and ocean fisheries, hastens eutrophication of water bodies, silts harbors and estuaries, and causes a host of other problems. An effective program requires a priority determination of where the off-site damages are worst and which degraded lands are responsible for those damages. Practically all offsite damage due to land degradation results from water and wind erosion. Human-induced salinization can also significantly affect downstream water quality, but such occurrences probably are rather inextensive.

Focussing on off-site damages can generate greater public support for on-site soil conservation because off-site effects are more easily seen to be important. A sand storm that closes airports and triggers allergenic reactions in people is easier to identify with than sand-filled furrows in a farmer's field. Wealthy countries also can concern themselves with important issues of biological diversity, endangered species, resource pollution, and developing a conservation ethic. There is little worry that continued land degradation threatens their food supply in the immediate future.

Poor developing countries should take a radically different approach. Governments should stop making a fuss about desertification except as it provides them a rallying cry for what they really need: economic development. Although increasing agricultural production to raise purchasing power is the key factor for rural-dominated societies, economic development may benefit more from building a good all-weather road system than from hiring more extension agents. Perhaps the most difficult change to achieve is to persuade political leaders that rural well-being is essential for a strong economy. The more usual objective of politicians in developing countries is to cater to urban populations because city people can start riots and overthrow governments.

Emphasizing intensification of agricultural production on the better lands makes it easier to control degradation and attain the goal of sustainable development. Desertification – as a subject of major concern – can be shunted aside for the present. One compelling reason for doing so is the lack of knowledge at higher levels of government about the extent and severity of land degradation in their

countries. African countries, in particular, decry desertification even though they may have little understanding of the relative importance of different desertification processes, the timeframe and costs of reversing degradation, the difference between drought and desertification, and the magnitude of the damage desertification has done. Governments do understand food shortages and believe they know how to increase agricultural production.

Land degradation control in poor developing countries probably can best be left to nongovernmental organizations (NGOs). NGOs are action oriented, think small, involve local people, usually learn from their mistakes, and operate on low budgets.

6. Conclusions

Land degradation is a global problem whose precise dimensions are unknown and for which there is no easy solution. The principles of desertification control are well known. Just as the causes and effects of land degradation in the drylands are site specific, so are the local control practices.

Despite the availability of control methods, land degradation continues almost unabated. The two major reasons land degradation control is not practiced appear to be a perception that the problem is not a serious one and a belief that control is not economic. The latter reason is a good one because it is generally true. The perception may or may not be correct.

My contention is that the best way to improve degraded marginal land is to reduce the pressure to exploit those lands. An obvious need is to control population growth, which can have a long-term effect. For the immediate future, land pressures can be reduced only by increasing the productivity of the best land. Practically every country has some land with a good potential for crop and livestock production. Capitalizing on that situation by intensifying production there will improve the economic condition of the agriculturalists and accelerate national development. Such action will do nothing directly to reclaim degraded marginal lands but will allow that land to be used less intensively. Less intensive land use, in turn, will help the land heal.

Poor developing countries would do well to forget about desertification and focus attention on economic development. Desertification control can be left to NGOs, which are more attuned to local needs and priorities.

Developed countries are advised to emphasize off-site effects of land degradation, principally erosion, and generate support for on-site control. Off-site impacts are easier for the urban dweller to appreciate than a future threat of food shortages.

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