Soil Erosion Control: Observations from the US Experience

Gary C. Taylor[1]

Abstract: World population is expected to increase by 40 percent by the year 2000. The rate of expansion of new cropland is slowing down. Increased food requirements must therefore be met primarily through application of new technology and protection of cropland from the ravages of erosion and other forms of deterioration. The USA has recently completed 50 years of experience with major programmes to control erosion. The history of the establishment and evolution of those programmes within a changing political environment is briefly reviewed. The initial programmes were implemented in all areas of the USA. However, recent surveys have indicated that harmful rates of erosion are limited to approximately 20 percent of the cropland. Some progress has been made at targeting control efforts to areas of high on-farm erosion rates.

Introduction

In the years since the Second World War, much of the world has seen unprecedented progress in food production. In the face of rapidly increasing population, food production per capita has been maintained and increased. From 1950 to 1983, world population increased from 2500 million to 4700 million. But grain production actually increased from 248 kg per person to over 310 kg. That success story was accomplished by application of improved technology (including the use of new varieties, additional machinery, fertilizers, and other agricultural chemicals) and the use of additional land and water resources.

As we look ahead to continuing rapid world population growth, will those successful accomplishments be maintained? Media coverage of widespread hunger and starvation in Africa draws public attention to the cries of those who have been warning us for a number of years that food production cannot continue to increase indefinitely using the farming systems that are now widespread because of the continuing deterioration in the natural productivity of soil and water resources through erosion and salinization and the declines of forests and grasslands. The Worldwatch Institute (1984) warns that "over the past generation, erosion has increased until close to half of the world's cropland is losing topsoil at a debilitating rate."

The Problem Setting

World population is projected to increase to 6200 billion by the year 2000 (Urban and Vollrath, 1984). An increase in food production can be met by increasing the area of cropland used to produce food crops, by increasing the productivity of cropland used to produce food crops, and by protecting the productivity of cropland from the ravages of soil erosion, rising water tables, and salinization.

Urban and Vollrath (1984) conducted a systematic study of the patterns and trends in world cropland use. The data indicate that only half of the estimated 2500 million to 3400 million ha considered potentially arable is actually cultivated. However, the more productive agricultural land is now cultivated. The remainder is marginal in terms of soil quality, climate, topography, or distance from population centres. Urban and Vollrath concluded that the cost of significantly expanding the world cropland base would be high, financially and environmentally.

Cropland expansion was an important factor in the expansion of food production in 1960-80. The cropland base increased approximately 9 percent during that period. The rate of increase, however, has been gradually declining from 1.0 percent per year in the late 1950s to below 0.3 percent in the 1970s. Continuation of that trend would lead to rates of 0.2 percent in the 1980s and 0.15 percent in the 1990s. If that projection proves to be accurate, only 50 million to 60 million ha (about 4 percent) are likely to be added to the 1980 cultivated cropland base by the year 2000.

Since cropland expansion is a rapidly declining factor in the increase of food production, maintaining the present productivity of producing areas through conservation and increasing potential productivity per unit of cropland through research and development are essential. The relative importance of the two strategies varies greatly, depending on the countries and farming areas involved.

The balance of this paper will consider the question of maintaining the inherent productivity of cropland with emphasis on the soil erosion problem. The USA has recently completed a 50-year history of substantial national effort to combat soil erosion. Public debate has recently flared again on soil conservation issues because the USA has not controlled its soil erosion.

Soil Erosion Control in the USA

The deterioration of soil productivity through erosion losses has been recognized by US agricultural leaders for more than 200 years. But undeveloped lands were abundant, and little concern was seen to be justified as long as new lands were available. The politically opportune moment arrived with the great economic crises of the 1930s. The farm economy was devastated. Great dust storms mobilized public concern about soil erosion.

The US Soil Conservation Service (SCS) was established in 1935 in USDA. The agency was staffed from the beginning with well-trained specialists who were charged with responsibilities to provide technical assistance to farmers, develop demonstration projects, and educate the public on erosion problems and their control (Griffin and Stoll, 1984).

In concert with the US system of state and local governments, the policy of SCS was to provide assistance only on request from soil conservation districts, which were usually organized on a county basis under state laws and governed by elected boards of directors. Formulation of districts proceeded rapidly, and the country was blanketed by some 3,000 districts in a few years.

At the same time that SCS was formed, radical new programmes for the control of agricultural production and the provision of subsidies to farmers were established using a similar system of elected committees at state and county levels. Significant federal funds were channelled through that system to provide financial incentives to undertake soil conserving practices. In addition, loan programmes were instituted to assist farmers, and federal and state research efforts led to the development of more effective and more economical approaches to soil conservation.

The first 30 years of the US soil conservation effort saw the establishment of programmes of technical assistance and financial incentives. The technical assistance was provided by well-trained specialists, usually the offspring of farmers, who were backed by active research programmes. Farmer cooperation was voluntary. Technical assistance and subsidy programmes were controlled at the local and state levels by farmer-elected committees. The vast majority of the funding was provided by the federal government. Considerable progress was made during that period in improving the knowledge of US soil resources, developing scientifically based practices for controlling erosion, and applying soil conservation practices on US farms.

During the 1960s, that system began to come under political stress. Rapid migration of farm families to other occupations began to lead to a weakening of the political strength of the farming community. The increasing strength of the environmental movement led urban people to become interested in soil erosion in terms of its impact off the farm on water quality, fisheries, and the siltation of reservoirs and waterways. The environmentalists were joined by other nonfarm interests concerned with shortages of public funds to support federal programmes that they thought to be more important than soil erosion control.

By the mid-1970s, burgeoning demands for agricultural exports led to the expansion of cropland and some destruction of existing conservation practices, notably terraces and wind breaks. Soil erosion was increasing. SCS was directed by the Soil and Water Resource Conservation Act to carry out systematic assessments of the soil erosion situation and to recommend programme changes. A national resources inventory (NRI) was undertaken in 1977 and again in 1982. The 1982 NRI involved field observations of soil conditions and land use on 841,000 sample points throughout the country.

The NRI used the concept of tolerance (*T*). Erosion is a naturally occurring geological process, while, at the same time, soils are continually being formed in place. Thus, a rate of erosion exists below which erosion losses do not affect the long-term inherent productivity of the soil for crops. The tolerance (*T*) level of erosion varies with different soils, but, under US conditions, the permissible *T* level of erosion is thought to average 4 or 5 t of soil per acre per year.

Erosion rates depend on natural factors such as soil materials, slope and length of slope, rainfall, and wind velocity. The rates also depend on institutional factors such as land use, crop mix, management practices, and conservation measures.

Using the 1982 NRI data, Heimlich and Bills (1984) found that a very large proportion of US cropland is probably not suffering a long-term loss of productivity from erosion. Cropland soils were classified as nonerosive, moderately erosive, and highly erosive. The moderately erosive class was subdivided into erosion rates above and below tolerance levels attributed to management practices (Table 1, p. 116).

Nearly 80 percent of US cropland had no long-term erosion problem in 1982.[2] Erosion rates on about 15 percent can be reduced to tolerance levels through changed management practices. The remaining 7 percent of cropland soils are so inherently erosive that the only viable way to control erosion is to change the land use to permanent grass or tree cover.

New comprehensive data indicate that the threat of erosion to long-term productivity of cropland is confined to about 20 percent of the existing cropland. Other studies have established that, indeed, the present system has resulted in establishment of significant amounts of conservation practices on croplands where they are not needed (Cook, 1981).

A Systems Approach to Studying the Costs of Soil Erosion

The erosion process moves soil particles by water or wind from the parent material ultimately to some body of deep water. The exact dimensions of that process are presently unknown, but sediment movement results in beneficial and adverse impacts along the way. US midwestern farmers joke that new dust storms from the western plains would increase the fertility of their lands!

The NRI data were collected at sample *points*. Several multidisciplinary modelling efforts are greatly increasing the sophistication with which we can evaluate the productivity impacts of soil loss from a particular soil at a particular point (Williams *et al.*, 1983). However, when soil is eroded from a sloping field, much of the sediment may be deposited lower down in that field or in adjacent fields. Productivity at the source of sediment has probably been reduced. Productivity in the area of deposition may either have been improved or have been damaged (Onstad *et al.*, 1984).

We know that soil erosion may damage growing crops, soil movement tends to increase the variability of soils within fields (which complicates crop management), and the formation of small gullies increases deterioration of machinery. However, we do not fully understand the on-farm impacts of soil erosion.

In addition, relatively little quantified information is available on the off-farm impacts of soil erosion. Information is needed on the impacts of sediment on reservoirs, irrigation systems, drainage ditches, roads, fisheries, and urban and industrial water supplies. Crosson (1984) estimated that those types of damages in the USA were in a range from $2000 million to $6000 million. The extent of the range of the estimate reflects the current imprecision that characterizes that type of

Table 1—Cropland by Soil Erosion Class and Gross Erosion Rate, USA, 1982 National Resources Inventory*

Annual Soil Loss (t/acre)	Nonerosive Cropland	Moderately Erosive Cropland		Highly Erosive Cropland
		Managed < T	Managed > T	
		--- 1000 Acres ---		
< 5	165,136	163,626	–	–
5-13	–	–	54,988	10,026
14-24	–	–	5,872	8,809
> 24	–	–	85	10,905
		--- Percent ---		
< 5	38	39	–	–
5-13	–	–	13	2
14-24	–	–	1	2
> 24	–	–	–	3

[*Erosion classes are based on inherent erosiveness and management relative to a 5 t/acre/year tolerance level. Source: Heimlich and Bills, 1984.]

information. That range is much greater than the range of dollar estimates of the long-term annual productivity losses from erosion on US farms (within the current environment of prices and technology).

The NRI-based analyses indicate that, from a physical viewpoint, the erosion problem is limited to some 20 percent of cropland. Predictably, that information led to calls for reform of the present system to target assistance to where the problems are located, and some shifts in the direction of targeting more efforts to areas of high erosion rates have occurred.

The use of on-farm physical erosion rates is inadequate to delineate an economically desirable level of erosion control. Productivity of some deep soils is not significantly damaged by high erosion rates. The impact of movement and deposition of sediment within fields and farms is not sufficiently well understood to determine optimum control levels. Information on off-farm impacts is only beginning to be assembled. We need to increase our understanding and quantification of sediment movement from the parent material to the ultimate point of deposition.

A reorientation of the present erosion control programmes from allocation of efforts uniformly over political jurisdictions to a targeting criterion emphasizing areas with high rates of erosion losses may also prove to be economically wasteful. Much more research and data collection are needed within the context of sediment movement as a natural process, with due consideration of all economic impacts, both on and off the farm.

Concluding Remarks

World food requirements during the next generation will require significant increases in agricultural production. The potential for bringing new cropland into production appears to be limited. If food requirements are to be met, increased emphasis will be required to improve agricultural technology through research and development and to maintain the productive capacity of croplands. The US experience in erosion control indicates the need to define the targets in terms of erosion-created economic problems both on and off the farm and to support soil erosion control efforts with research and data collection programmes. Erosion control efforts must be targeted to problem areas recognizing unique natural, economic, and cultural (political) conditions.

Notes

[1]Economic Research Service, USDA.

[2]The results are limited to sheet and rill erosion. The impacts of less important gully and wind erosion are not presently known on a comprehensive basis.

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Discussion Opening – *Steven E. Kraft*

The comments of Söderbaum recall Walter Firey's spelling out of the logical basis for separate and conflicting analyses of patterns of resource use. The conflict arose out of what Firey identified as three divergent perspectives on resource utilization: the ecological, the ethnographic, and the economic. He demonstrated that each perspective has its internal logic resulting in a set of "acceptable" resource uses that may be at variance with those acceptable from the other perspectives. In short, no *a priori* reason exists to expect that forms of resource utilization that are deemed ecologically optimal will be coincident with forms that are judged to be ethnographically or economically optimal. The dance of politics involves reconciling or ignoring the existing differences.

In the USA since February 1981 under Executive Order 12291 requiring benefit-cost analysis of all significant regulatory actions, we have seen a new ascendancy in the economic over the ecological and the ethnographic. The tyranny of discounting and monetary reductionism precludes extensive consideration of either of the alternative perspectives. Consequently, concerns with questions of equity, intergenerational externalities and equity, and resource use and nonmonetized externalities are frequently ignored or left to be factored into the analysis by political decision makers.

A number of issues can be raised in regard to soil conservation. While Taylor indicates that a small proportion of US cropland is the largest source of soil loss and its accompanying off-site damages, he overlooks the conservation reserve that has been proposed to deal with that problem. The conservation reserve is designed to shift highly erosive land from intensive row crop production to less erosive uses (i.e., forage production and woodlots). Since highly erosive lands are not generally randomly distributed throughout agricultural areas, a conservation reserve programme could have significant economic consequences for regions with large concentrations of highly erosive lands. The land use shifts inherent in the conservation reserve could have disruptive effects on the input supply and output handling sectors of regional agricultural economies. Given the already depressed nature of the economies of many rural areas closely tied to agriculture, those disruptions will exacerbate that depressed state. On a more micro level, the impact on the economy of individual farms could be extensive, especially for farmers who responded to the food crisis of the early 1970s and expanded their operations by bringing "marginal but erosive" land into production. Frequently, those farmers have assumed financial obligations justified on the basis of expanded, intensive crop production. A shift to less intensive use of the erosive lands will make it difficult for many of those farmers to service the debt acquired under the expectation of continued intensive use of the land.

While multidisciplinary modelling efforts are useful in evaluating different conservation policy alternatives and assessing the relative effectiveness of conservation practices, such efforts largely ignore the farm operator or landowner as well as local agency personnel and their supportive, locally-constituted committees. When a policy is selected through the combined effects of modelling and political deal making, the successful implementation of the policy rests with the responses of those people. Evidence from recent research suggests that agency contact with farmers is useful in getting conservation on the land. However, within a population of farmers, agency contact runs at the level of about 50 percent. Similarly, data on the allocation of US conservation programme funds for cost sharing with farmers on conservation practices suggest that local committees making the allocative decisions have not made the best use of available funds. When talking about targeting on a county or hydrological basis, or in terms of microtargeting within watersheds, comprehensive attention must be given to the capacity of the existing locally-constituted bureaucratic structure to implement and deliver the required programmes.

General Discussion – *J.P. Chassany* and *S. Nidenberg*, Rapporteurs

Economic evaluation of environment was the central point of the discussion. Some questions were based more on concrete elements (i.e., erosion of soils and self-pollution in the case of aquaculture). Other questions concerned more general conceptual and methodological considerations.

Questions were raised about soil conservation in the USA, especially on the usefulness of the soil erosion classification and soil conservation policy measures. The idea of a socially acceptable erosion limit constitutes an original approach.

Another point raised by some participants was that the papers presented should have considered the impact of rapidly increasing population on the environment factors, which appears fundamental. In particular, the interest of considering the relations between technological and social changes was stressed.

One has to bear in mind that the historical study of certain landscapes in countries of ancient rural civilizations shows that some of the equilibria between nature and society seem to be fragile or even destroyed because of the impact of market economies.

Other participants asked questions on the possibility of evaluating environmental changes (e.g., by taking into account unpredictable events) by association of monetary and nonmonetary evaluations, such as the holistic type presented by Söderbaum. Söderbaum replied that such criteria are used in his country with regard to transportation infrastructure, though policy makers continue to rely on cost-benefit analyses.

The problem remains of finding a way to compare monetary and nonmonetary values, since there is no reference to a market price.

A question was raised about the possibility of evaluating irreversible ecological effects. Söderbaum replied that it is necessary to first consider a nonmonetary evaluation.

All agreed that the general evaluation problem is very difficult, especially when one has to suggest policy decisions. The institutional approach is interesting for policy makers, but it is necessary to add the willingness-to-pay approach and the appreciation of monetary and nonmonetary benefits.

More generally, Anderson agreed with a holistic approach, which is important for the analysis of resource exploitation. To that end, the paper he presented represents only one small part of the analysis: an attempt to use analytical techniques to derive some intuition as to the behaviour of the natural commercial fishing industry faced with a competitive new technology. The results do not make a statement about the socially optimal solution. However, applying such techniques from the point of view of different actors (public and private) with different structures can help to define a set of several strategies that might then be used in a more holistic analysis.

Taylor, from a technical point of view, remarked that society must make a choice among the recommendations he made, but one has to assume that politicians are representatives of society.

Generally speaking, since the most important technological and sociological changes should be observed in developing countries, a high standard of living could be sustained in the least developed countries as well as in the developed countries with minimal environmental costs.

In conclusion, the participants were very interested in the exchange of ideas on the theme of environmental evaluation, chiefly with a holistic approach, and suggested that it should take more importance in the next conference.

Participants in the discussion included M. Ahearn, A. Anderson, J. Berthelot, R.A.A. Boschi, L. Drake, J. Hildebrand, P. Power, G.T. Rafsnider, B. Roux, E. Tambo, and G. Weinschenck.