Impact of Exploitive Farming Practices on Soil, Water, and Crop Quality: A Need for Remedial Measures

S. Wicherek and M.-O. Bossier
Biogeography-Ecology Center National Center For Scientific Research (CNRS)
Saint-Cloud, Paris, France

Abstract

Currently, many of the major agricultural areas of North America, northern and eastern Europe, and northern China are being degraded by excessive soil erosion which has lead to a progressive loss of natural fertility and decline in productivity. This is being compensated for by the use of chemical fertilizers and pesticides which can adversely affect the quality of surface water and groundwater. The degraded soil and polluted water can directly impact the safety and quality of vegetables grown and, in turn, human and animal health. What is the cause of this? Man himself. It began in North America in the 1930's with the introduction of intensive and extensive farming; and in the 1970's in western Europe with re-zoning and changes in agricultural customs and practices. Thus it is important now that eastern Europe carefully assess its emerging agricultural management systems to avoid these same mistakes. The question is what can be done, or should be done, to resolve the problems of exploitive farming practices without disrupting the socioeconomic systems already in place? Solutions do exist. Numerous trials have been conducted at the field, watershed and community levels (some by the Biogeography-Ecology Center) to improve the utilization, conservation, and protection of the rural environment. The main focus is to facilitate the development of a more sustainable agriculture that is essential to economic development worldwide. It is a matter of common interest and concern that we address the real problems that threaten our natural resource base and environment, and initiate proper remedial measures.

Introduction

The northern hemisphere contains an expanse of fertile agricultural land and a temperate climate that allows the production of a wide range of crops. The potentially arable land comprises about 22 percent of the total land surface; however, only half of the arable land is actually cultivated. The soils of some areas can support economic yields of crops without the addition of chemical fertilizers because of their high indigenous fertility levels (e.g., 1200 kg ha^{-1} wheat yields are not uncommon). Productivity increases in relation to natural soil quality, favorable climatic factors, improved farming methods and in-puts of chemical fertilizer. The largest agricultural areas are those of the United States Great Plains, the Canadian northern plains, the northwestern and eastern European plains (i.e., steppes), and the plains of northern China. The greatest agricultural potential is found largely in the most industrialized and economically-developed countries as shown in Table 1 (Beaujeau-Garnier et al.,1992).

Table 1: The Agriculture Potential of the Most Industrialized and Developed Counties in Terms of Total Land Area, Agricultural and Arable Land, and Their Respective Populations Involved in Agriculture (Adapted from Beaujeau-Garnier et al., 1992)

Country or Community	Population (%)	Total Land Area (x 1000 km^2)	Total Agric. Area (%)	Arable Land (%)	Population in Agric. (%)
European Union	346	2,260	58	53	7.4
Eastern Europe	137	1,246	69	65	18
Russia	284	22,275	27	62	15
USA	255	9,372	46	48	2.9
Japan	124	372	15	51	7.9
China	1,166	9,596	33	11	61
Canada	27	9,959	5	85	6
France	57	551	59	56	3.6

The data summarized in Table 1 provides an assessment of the agricultural situation that exists in industrialized countries where there is an abundance of fertile agricultural lands and favorable temperate climates for extensive crop production. It is noteworthy that Europe (including France) has the potential arable land, human resources, favorable climate, and highly developed food processing industries to play a major role in world class agriculture. However, this will depend on whether we can develop a truly sustain-able agriculture, i.e., economically, environmentally, and socially sustainable.

Agriculture and Environmental Relationships in Europe and France

Beginning in neolithic times, early Europeans began to clear the land for cultivation of crops. Over the centuries, farming practices intensified in an effort to produce food for expanding populations. Intensive agricultural production practices eventually caused excessive soil erosion, degradation of soil quality and a decline in soil productivity (Chisci and Morgan, 1986). While earlier generations of peasants had closely adjusted their farming systems to local conditions, the intensification of agricultural production and the concomitant transformation of this rural society has virtually eliminated the diverse patch-work of small farms that once existed. Today, vast areas of cropland alternate with large forests, extending their bioclimatic differences and biodiversity over even greater areas. This has resulted in large tracts of land left vacant by a decline in the population of small farmers. In time, these abandoned lands became spontaneously or voluntarily wooded, and today the villages are surrounded by small fields or plots situated between large forests and major cropping areas (i.e., large fields). This is the new rural landscape that has evolved on the plains of Europe.

These changes have had serious repercussions on agriculture and the environment. Because there is now a lack of permanent vegetative cover, much of the rainfall no longer infiltrates into the soil but runs off into streams carrying with it the topsoil, organic matter and plant nutrients (Wicherek, 1993). Consequently, to maintain soil fertility at acceptable levels, farmers have applied increasing inputs of chemical fertilizers which, when carried away by rain, contribute to the pollution of surface waters and ground-water. Moreover, the extensive use of chemical fertilizers and pesticides has raised concerns about food safety and quality, and human and animal health.

New farming methods and practices have also aggravated the situation. The passage of increasingly heavier machinery over the land has caused severe soil compaction reducing its permeability to air and water as much as 30 centimeters below the surface. Again, this has accelerated the runoff of rainfall because infiltration is restricted. This, in part, accounts for the floods and mud slides that France has suffered in recent years which were virtually unknown a few decades ago (Wicherek, 1989, 1993).

The northwestern European plains which comprise major cropping areas have long been considered a stable environment. However, during the past 20 years their soils have undergone extensive degradation largely from intensive tillage and subsequent erosion, and from re-zoning. In western Europe, the decision-makers have not given sufficient attention to these problems; yet some 25 million hectares of farmland have been adversely affected by soil erosion (Wicherek, 1989). In the Mediterranean Region the results of severe soil erosion by water are clearly evident due to the mountainous terrain and climate. Wind erosion is usually limited to littoral zones. The annual cost of progressive soil erosion in western Europe is estimated at 10 billion French francs.

While the phenomenon of soil degradation is less publicized in France than “acid rain” or forest fires, it’s implications are equally disturbing, particularly in the food processing sector. In the early 1950’s the total land area that had been damaged by water erosion, especially in southeastern France and the mountainous regions, was estimated at about 2.7 million hectares. Recent research conducted by our Center has shown that the extent of soil erosion by water in the Parisian Basin has adversely affected some 5 million hectares. Soil erosion rates in this area have often ranged from 30 to 50 tons per hectare per year.

In the future, those soils with good agricultural potential will likely increase dramatically in value, particularly if countries of the southern hemisphere are not able to substantially increase their food production capabilities.

Research to Improve Soil Quality

A closer look at what actually happens to soils in the process of erosion is relevant. Soil fertility and productivity depend on the relationships that exist among their component parts including plant nutrients, water, gases (e.g., oxygen, nitrogen, and carbon dioxide), organic matter, inorganic material (e.g., sand, silt and clay), and the soil micro- and macrobiota. Soils that are most resistant to erosion usually have a highly developed structural stability which results from an assemblage of solid mineral particles bound together by clay and humus. A granular structure facilitates the entry and movement of water and air, and decreases the potential for surface runoff and erosion. Thus, the most fragile soils that are highly susceptible to erosion contain little humus (often less than 2%) or clay, but a large percentage of fine sands.

Rainwater is the main cause of soil erosion. The kinetic energy of raindrop impact breaks down the soil aggregates into individual particles which are then easily transported by surface water flow. The extent of erosion is directly related to the steepness of slope which increases the water flow and velocity and, consequently, it’s erosivity (Wicherek, 1994). A dense vegetative cover or canopy including grass, trees or crops can effectively protect the soil from erosion (Wicherek, 1988). Such vegetative barriers help to intercept the raindrops and disperse their kinetic energy, thereby reducing erosion, runoff and sediment transport. Without this protection, the bare soils are highly susceptible to erosion especially where rainfall intensity might exceed 15 mm per hour. Soils that are especially erodible are often those cropped to cereals, maize, sugarbeets and potatoes, mainly due to the extra time needed for canopy closure.

The natural fertility of soils and water quality tend to decline as chemical fertilizers and pesticides are applied. Farmers in western Europe apply an average of 500 kg of N-P-K and 3 kg of pesticides per hectare per year. Only about 75 percent (or less) of the chemical fertilizer applied is actually utilized by the crop, the remainder being a potential pollutant. Researchers need to link the nutritional requirements of crops at specific stages of plant growth to determine the best time and dosage of chemical fertilizers to apply. This would help to avoid excessive use of chemical fertilizers and reduce their potential as environmental pollutants. Moreover, the macrofauna (e.g., earthworms) and microfauna (e.g., animals less than 0.2 mm such as protozoa and some nematodes) are vital for maintaining a favorable biodiversity in soil and recycling organic matter. However, their numbers are often diminished because of the adverse effects of chemical fertilizers and pesticides.

For some years now our Center has studied these phenomena, relationships, and interaction parameters concerning soil erosion and water quality. We have done so on various levels including field plots, watersheds, communities and regions. This has provided a better understanding and appreciation of the spatial and temporal relationships and their correlation with physical measurements (Wicherek and Laverdiere, 1993). Also, we utilize satellite photography and particularly Cs-137 fallout patterns which provide an excellent assessment of soil degradation and environmental pollution (Wicherek et al., 1993). The Cs-137 isotope helps us to interpret our results and refine our typology of agrarian zones by establishing quantitative and qualitative agricultural classifications.

Soil and Water Management Practices for More Sustainable Agriculture

Our current knowledge of land degradation in North America and western Europe allows a firm basis for improved management of rural areas (Boardnlan et al., 1990; Wicherek, 1994). Presently, several rural communities in the Parisian Basin (in Laonnois and Soissonnais) are being evaluated in this regard. Soil tillage plays a fundamental role; while it may improve soil structure, permeability and rooting depth, it can also accelerate mineralization (of organic matter), compaction and erosion. Soil structure can also be improved by the addition of certain mineral amendments (e.g., limestone and gypsum) and organic amendments (e.g., animal manures, green manures, crop residues and composts). These amendments help to protect the soil from erosion and enhance soil fertility and productivity.

Surveys indicate that the threshold figure at which a loss in net profits begins to seriously impact farmers is about 5 percent. However, farmers may readily modify their practices to overcome and avoid the impacts of soil erosion. A reduction in the use of heavy machinery often results in improved soil structure. Additional benefits are obtained by positioning harrows under the plow to break up the compacted impermeable layer beneath the surface, and using lighter machinery to avoid compaction. Reduced tillage and direct sowing (without primary tillage) are being evaluated at experimental farms in western European countries including Belgium and Germany.

Cross-slope or contour tillage operations can greatly minimize soil erosion and are highly recommended based on studies conducted in the United States and western Europe. Careful selection of crops is important to provide maximum vegetative cover for protecting soils from erosion during wet seasons. Proper division and zoning of agricultural areas can help considerably to minimize or control soil degradative processes such as erosion.

Permanent vegetative cover is most effective in preventing soil erosion and can be an integral part of the cropping cycle (Wicherek, 1988). It is evident that the elimination of herbaceous species of hedges and taluses has aggravated flooding and mud slides in several European regions. Slopes favor erosion and slope steepness is more important than slope length, provided that furrows are oriented properly. Topographic location is also important; the bottoms of slopes are often more quickly saturated and eroded than the tops. We need to reassess the classical land improvement models. Moreover, we need to reconsider our approaches to tillage methods (i.e., reduced tillage vs. intensive and shal-10w vs. deep), use of organic amendments and mulches, biological factors and biodiversity, and amelioration of soil crusting and compaction.

Conclusions

Scientists and decision-makers are just beginning to be aware of the socioeconomic aspects of soil erosion; the financial aspects are only just being broached in Europe. This can be explained by the fact that scientific research in this domain is not widespread, in-formation is limited and the regulations are insufficient and unsuitable. For example, in the global policy of the world market, the cost of erosion (loss of productivity in the short- and long-term) and the cost of controlling erosion have hardly been integrated into political decisions and GATT (General Agreement on Tariffs and Trade) negotiations.

Soil degradation is without doubt a societal problem. It is a question of managing and conserving water quality, while at the same time managing the quality, fertility and productivity of the land. Controlling soil erosion is one of the keys to the development of sustainable agriculture. Several actors are concerned here; the researchers, who need to better understand the mechanisms to be able to offer concrete solutions; the politicians, who must make decisions (for example; making the polluter pay); and farmers, who must improve their land use management practices, taking into account the gravity of the problem and the large costs generated by soil erosion. Farmers appear to be ready to collaborate with the decision-makers and scientists. Let us hope that the present day generation will tackle the real problems of the earth; that they will learn to manage and utilize the land which nurtures us and to develop the knowledge and technology indispensable for conserving soil quality for future generations.

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