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Socio-economic factors in soil erosion and conservation

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Abstract

Farmer decisions with regard to production and land use are strongly influenced by socio-economic factors. In the developed world, the role of agricultural subsidies, quotas and guaranteed prices is especially important. In the past there have been many examples of economic signals which led to unfortunate and unforeseen environmental consequences ('perverse subsidies'), including soil erosion. The problems were neglected because of an emphasis on increases in productivity and the fact that many of the costs were hidden or were external to the farm and were borne by society. In recent years 'agri-environmental measures' have begun to reverse the trend towards environmental degradation.

Keywords: Soil erosion; Runoff; Agricultural policy; Soil conservation; Agri-environmental measures

Although land degradation is a physical process, its underlying causes are firmly rooted in the socio-economic, political and cultural environment in which land users operate (Stocking and Murnaghan, 2001, p. 25)

1. Introduction

Land degradation and in particular, soil erosion, has a long history of being studied as a physical process by scientists from backgrounds as diverse as geography, geology, agronomy and engineering. With access to modern technology many such scientists have utilised computer technology to process data, to model physical systems, and to predict current or future rates of erosion. The development of specialised academic journals, not to mention university departments and government research institutes, has given impetus to this trend. Impressive results have been achieved in terms of understanding of erosional processes, modelling and prediction.

Nonetheless it has long been recognised, that focusing exclusively on physical processes offers only a partial explanation of the causes of degradation. At its simplest, any physical scientist will recognise the role played by crop cover or vegetation density in initiating or controlling erosion, and it is quite clear that this factor is strongly influenced by farmers and graziers who are responding to socio-economic factors. The question that then arises is, why do managers allow land to be in a vulnerable state? Is this mere risk-taking with the odds heavily in their favour? Or are socio-economic factors encouraging managers to take the risk whatever the odds?

The socio-economic and physical factors which drive soil erosion therefore need to be addressed in tandem. Perhaps for reasons of disciplinary protectionism, it is rare that a study attempts to do this. However, Evans (1996) made an attempt with his assessment of the socio-economic and physical drivers, impacts and costs of erosion for UK and Wales. This covered both the present and the past, and outlined how the present-day impacts could be alleviated. The study was based on field-based information, rather than computer models.

When predicting the impacts of land use and land use change on soil loss by water erosion, almost always it is only sheet and rill erosion that is considered. This is because most predictive studies employ computer models of erosion, and most existing erosion models focus only on these processes. Over the last decade, it has become clear from several monitoring studies that other processes also play an important role in eroding soil under particular land uses, i.e. ephemeral gully and gully erosion (e.g. Nachtergaele and Poesen, 1999), piping (Faulkner et al., 2003), soil loss by land levelling (e.g. Poesen and Hooke, 1997), soil loss by

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tillage erosion (e.g. Poesen et al., 1997), and soil loss by harvesting roots (e.g. sugar beet) and tubers (e.g. potatoes) (e.g. Poesen et al., 2001).

This volume aims to explore the influence of socio-economic factors on erosional processes and conservation measures, mainly but not exclusively, in a western European farming context.

2. Socio-economic factors

Stocking and Murnaghan (2001) discuss the factors affecting land users and land degradation. Their discussion relates primarily to developing countries but it is valuable to consider the list of factors, some of which are clearly relevant to the Developed World (Table 1). Of the factors listed it would seem that Developed World farmers are far more influenced by economic incentives than any others. Farmers react very quickly to changes in price incentives and within the constraints of topography, soils, rainfall, access to markets etc. will rapidly adapt crops and practices to changes in market prices and quota arrangements. In western Europe farmers have reacted in this way in growing crops such as sugar beet, linseed and potatoes. In many countries, the important move away from mixed farming with livestock and grass, and into predominantly arable systems, is driven by socio-economic factors operating both at a national and local scale (e.g. Souchere et al., 2003; Mathieu and Joannon, 2003).

3. Land-use policies

The most direct socio-economic influence on the land manager is via land-use policies be they explicitly stated as constraints or, more frequently, implicit in strong economic signals such as subsidies, guaranteed prices or protectionist policies. Farmers have to make a living and will therefore make decisions on the basis of what crops give the best economic return. The problem is that often these price signals do not take into account impacts on the environment. There are many examples in Europe of the encouragement of certain crops or practices leading directly to degradation: what Myers and Kent (1998) call ‘perverse subsidies’ (Table 2). Why does degradation happen?

- Conventional cultivation techniques (compared to no-till or minimum-till), expose bare soil to wind or rain; the timing of cultivation vis a vis rain or wind will then be critical.
- Farming practices associated with some crops encourage runoff and erosion e.g. the cultivation of sugar beet and potatoes in rows and ridges which channel runoff; the removal of competing weeds and grass from soil between vines and almonds; and the de-stoning of soils for potato cultivation.
- The favoured crops may be inherently high risk in terms of generating runoff and erosion because of the distance apart of individual plants e.g. maize, therefore offering little protection to the bare soil surface.

Thus, it may be that it is the socio-economic factors that influence the choice of crops and the way in which the crop is grown can lead to unforeseen problems of runoff and erosion.

Crops such as winter cereals would normally be regarded as offering a good protection against erosion, and indeed in Belgium, Bielders et al. (2003) describe the change from winter to spring cropping as increasing the risk of erosion. However, in the British Isles, a combination of land-use decisions, driven by the economic imperative, and the

Table 1
Factors affecting land users and land degradation (adapted from Stocking and Murnaghan, 2001)

Factors	Relevance of factor to Developed World (DW)
Land tenure	No evidence in DW that owners rather than tenants have conserved the soil (security of tenure?); upland common land has been degraded by overstocking
Poverty	*Relative* poverty in DW encourages farmers to concentrate on immediate needs; land abandonment has led to erosion, e.g. in Mediterranean
Pressure on the land	Changes in technology, rather than rural population increases in DW, have led to degradation; agricultural intensification is related to desire to increase crop yields
Labour availability	Hardly relevant in most of DW; but abandonment of terrace systems due to rural depopulation has led to erosion
Economic incentives	Major price support incentives for production of ‘cheap food’ in protected markets have strongly influenced DW agriculture encouraging ‘short-termism’ and neglect of conservation
Indigenous technical knowledge	Traditional practices which conserved soils have been abandoned in face of technological change and price incentives
Appropriateness of introduced technology	Introduced technology has largely been productivity-related
Economic and financial returns	Low erosion rates and off-site impacts do not encourage farmers to invest in conservation (a rational, short-term, economic decision)
Off-site vs. on-site costs	On-site costs of degradation are low and off-site costs generally regarded as a cost to society not the individual farmer
Power and social status	Less relevant in DW

Table 2
Impact of land use in Europe on erosion and runoff: some examples

Land use (or abuse)	Area	Impact
Almonds on steep slopes	Southeast Spain (Faulkner, 1995)	Soil loss
Winter cereals	South Downs, UK (Boardman, 1990, 2000; Evans, 1996)	Soil loss and muddy floods
Maize	Belgium (Nachtergaele, 2001); northern France, southern UK (Boardman et al., 1996; Evans, 1996)	Muddy floods and pollution of watercourses (e.g. atrazine)
Land levelling and terracing	Norway (Lundekvam et al., 2003); Italy (Clarke and Rendell, 2000); Spain (Faulkner et al., 2003)	Erosion and pollution
Overgrazing	Iceland (Arnalds and Barkarson, 2003); UK uplands (Evans, 1997); Mediterranean	Erosion, drinking water pollution, loss of ecologically valued habitats
Collectivisation	Slovakia (Stankoviansky, 1997)	Erosion and muddy floods
Olive oil production	Spain (de Graaff and Eppink, 1999)	Erosion

late-autumn peak in rainfall, have acted in the opposite direction and combined to increase the risk of erosion with the spread of winter cereals. The removal of field boundaries to produce larger more easily worked spaces; the movement of cultivation onto steeper slopes as a result of more powerful farm vehicles; the desire for finer tilths (Frost and Speirs, 1984), and the fashion for post-drill rolling of crops, are all practices that accompany cereal cultivation and increase the risk of erosion. These apparently contradictory trends suggest that it is not the crop per se that strongly influences erosion, but the soil surface and landscape reorganisation that accompanies modern intensive farming.

In many areas, greater specialisation in agriculture and the demise of mixed farming systems has meant that blocks of land are cultivated in a similar manner at the same time thus increasing the risk of runoff from one bare field travelling across many (Boardman et al., 2003).

Physical constraints continue to influence farming decisions—thin and stony soils may not be suitable for high value vegetable crops thus reducing farming choice and increasing specialisation. However, the cultivation of several salad crops per year in Kent, UK, illustrates that with good soils and access to irrigation water, these constraints can be overcome. In such situations, erosion is an environmental cost resulting from constant cultivation of wet soils with heavy machinery (Boardman and Hazelden, 1986). It is a truism that UK consumers are not paying the true cost of production of these goods (e.g. Evans, 1995; Pretty et al., 2001; Environment Agency, 2002).

A spectacular example of the impact of government economic policy on land use and soil degradation is described by Meadows (2003) based on pioneering work by Talbot (1947). The Wheat Importation Restriction Act (1930) aimed to stabilize wheat prices at high levels. This acted as an incentive to South African farmers to cultivate unsuitable hillsides resulting in extensive gully erosion. The folly of the policy is aptly summarised by Talbot (1947, p. 41):

> The gullied hillsides, the wind-eroded lands, and the abandoned fields of today are a monument and an indictment of men who could stabilize wheat prices but were powerless to stabilize the soil.

4. Impacts of land-use policies

The impact of soil erosion is conventionally divided into on-site and off-site impacts. In many cases, this is equivalent to the distinction between impacts on the owner/manager of eroding land and on others who are affected. This may have legal implications since few societies take action against owners who allow their land to erode but many seek to protect others from the consequences of poor management by neighbours.

The impact of erosion may be at a great distance from the site of the erosion: socio-economic policies may therefore have an impact which is both spatially and temporally displaced (Table 3). This is often the case with dam sedimentation in that the site of the erosion may be any part of the catchment. Two things complicate the issue. Firstly, it is often difficult to be precise about the source of the sediment (and pollutants) and this may affect legal proceedings: total mean daily load (TMDL) legislation and practice runs into this problem in the US (Favis-Mortlock et al., 2001).

Table 3
Some impacts of land-use policies

	Spatial	Temporal
Proximal	Loss or burial of crop and fertilisers	Loss or burial of crops and fertilisers (some delays, e.g. until harvest); property damage
Distal	Property damage by muddy floods; dam siltation; eutrophication; water cleaning costs	Release of sediment and pollutants from storage sites; thinning of soil; nitrates in aquifers

Secondly, sediment and pollutants eroded at one site may take years before impacting downstream sites because of temporary storage en-route (Trimble, 1983).

Similarly, eutrophication of watercourses associated largely with phosphates (the latter often travelling in association with eroded soil particles), may take place far from the site of erosion. Pesticides, including atrazine, also travel attached to soil particles and cause pollution problems in watercourses and the sea (e.g. Evans, 2002). In the UK, policies put in place to protect wetlands have been frustrated by lack of controls over the wider catchment and over farming activities therein.

Nitrate pollution of aquifers can be regarded as an indirect consequence of erosion in that yields of crops are maintained on thin soils by application of nitrates. The impact on aquifers may be delayed for decades after application, due to the slow travel time through certain rocks (Foster, 2000).

5. Costs

Socio-economic policies reflected in land use are a major influence on how the land is farmed and therefore on erosion and pollution. Some of the external costs of farming can be directly related to erosion. Pretty et al. (2000) list these for the UK in 1996 (Table 4). These may be compared with (or added to) the £3 billion that taxpayers are spending annually on agricultural support in the UK (PCFFF, 2002, p. 13).

Some costs are unknown and at present difficult to quantify. Recent severe flooding in the UK raises the issue of the extent to which climate or land use is the cause (DEFRA, 2001). Given the precautionary principle it may be wise to plan for climate change but it is also clear that switches in land use, particularly from grassland to arable, have strong impacts on runoff and erosion. For example, Souchere et al. (2003) using the STREAM model, suggest that ploughing up of permanent grassland would lead to a rise in runoff volume (502–880 m^3) and soil loss (924–1708 kg) for a Normandy basin of 10 km^2. The same debate is rehearsed with reference to recent flooding in the Tisza basin in Hungary: climate or upstream forest clearance in the Ukraine (Fenyo, 2001)? Riverine flooding of towns is far more costly when sediment-laden water is involved, and in this case the costs (and benefits) of particular land uses and related erosion are not being taken into account.

Table 4
Selected external costs of UK agriculture, 1996

Cost category	UK (£ million)
Pesticides in drinking water	120
Nitrate in drinking water	16
Phosphate and soil in drinking water	55
Eutrophication	6
Monitoring and advice on pesticides and nutrients	11
Off-site damage caused by erosion	14
Organic matter and CO_2 losses from soils	82

Source: Pretty et al. (2000).

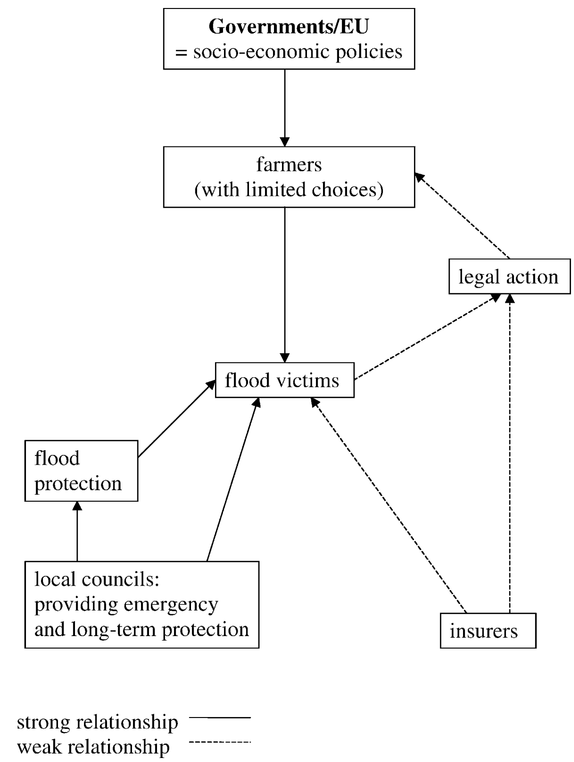

Fig. 1. Muddy floods in southern UK: actors and relationships.

One can argue that farmers, and land managers in general, driven by strong socio-economic signals have a direct responsibility for some part of the impact of runoff and eroded soil on downstream property (Fig. 1). This is far easier to demonstrate in the case of muddy flooding affecting nearby urban areas than with the case of major riverine flooding. Of some interest is whether pressure from flood victims and their insurers will feed-back to influence land use decisions and even government policy. Ironically, EU agri-environmental measures that are starting to influence land use and therefore runoff and erosion, are driven primarily by the need to reduce the food mountain and to a lesser extent by concerns about biodiversity, pollution and flooding.

6. Opportunities and challenges

Agricultural land in Europe varies greatly in monetary value. Agriculturally marginal areas are easy to deal with in terms of offering economic incentives for land use change, for diversification, and to bolster farmer incomes. Thus, overgrazing in upland areas is likely to be easier to address because of the perceived cultural value of these landscapes, alternative available land uses (national parks, etc.), and low farmer incomes. However, erosion tends to be low in these areas and impacts are felt at a distance, e.g. downstream water quality impacts and dam sedimentation.

The real, and more difficult challenge, is to address erosion and pollution issues on high value agricultural land. This is more difficult because farmers have little incentive to change land use or practices that are clearly successful in any short-term economic evaluation. It is the real challenge because erosion rates will tend to be higher on high value, fertile soils. For example, the easily worked loess soils of Belgium have a long history of erosion and erosion is still widespread. Similarly, with the Rioja wine area of northern Spain, and the intensive arable areas of the UK, the incentives to invest in conservation are few.

Socio-economic drivers may be used to discourage over exploitation of soils in situations where alternative land uses are economically viable and socially desirable. On the other hand, in areas with high value crops on fertile soils there will be little incentive to conserve. In some areas, soils have become almost irrelevant to farming with wholesale remodelling of landscapes to create flat, soil-less terraces and climate and water provision are the only issues with regard to successful agricultural production (see Faulkner et al., 2003). The emphasis may then shift to costs of inputs (water, labour, fertilisers), and outputs (polluted water and soil).

The socio-economic climate is changing in Europe. Farmers have been under intense economic pressure in many countries and enlargement of the EU is likely to increase that pressure. Many of the pressures are consumer-driven and include the demand for safe and healthy food, for organic food, for environmentally friendly landscapes (to protect biodiversity), and for clean water. However, government agencies and non-government organisations can also play an important role. Political attitudes to pollution and erosion may be changed in many different ways: in Denmark, the 'dead lobster incident' was important (Veihe et al., 2003). In Iceland, farmers have felt the need to retain public support for their industry (Arnalds and Barkarson, 2003). Pressures for change, transmitted to government (witness the increase in Green Parties and environmental pressure groups in many countries), provide opportunities for the design of reduced-impact farming.

This volume contains notable examples of successful responses to the challenge of erosion and pollution. Innovative solutions in the desertified areas of Iceland are now providing financial support for legally enforceable sheep numbers that aim to be sustainable (Arnalds and Barkarson, 2003). In Norway, perverse subsidies for land levelling have been replaced by support for minimum tillage in the autumn thus reducing runoff and erosion (Lundekvam et al., 2003). In Flanders, farmers are now enthusiastically joining soil conservation schemes whereas previously there had been a lack of interest (Verstraeten et al., 2003). In all of these cases, monitoring schemes are essential to ensure that public money is not wasted.

7. Conclusion

The last 60 years in much of Europe will be seen as a period when agriculture was successful in meeting the challenge of producing more food but at the expense of considerable degradation of soil and water resources. It has also become clear that many hidden costs incurred in producing the 'cheap' food were borne by society.

This situation is now changing although the economic drivers are still heavily biased towards support for production. However, this volume includes many examples of emerging good practice with regard to reducing erosion, associated water pollution and other off-site impacts. Common to many approaches is that they are underpinned by scientific assessment of the character, scale and location of the problem, and that they adopt a targeted approach, i.e. economic incentives are offered where certain criteria are met. The Icelandic approach to incentives based on extensive assessment of the scale of the problem, is a model of its kind (Arnalds and Barkarson, 2003).

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