11 FIELD ASSESSMENT OF EROSION AND SOIL PRODUCTIVITY FROM THE PERSPECTIVE OF THE LAND USER

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Abstract

Rapid and participatory ways of assessing soil erosion and its impact are needed in order better to represent the perspective of land users and how they make decisions on investing in conservation. A recently published 'Handbook for the Field Assessment of Land Degradation' is reported, which promotes a farmer-perspective approach that is realistic, better integrated, and more practical than standard assessments. Indicators are used that capture the time-scales of significance to farmers that focus on their concerns and are relatively simple to operate. The example of 'armour layers', the residue of stones left behind after sheet-wash, is described. These types of assessment provide more policy-relevant experiences of soil erosion and its impact, leading to a better future for the sustainability of land resources.

Introduction

Soil erosion and the consequent loss of productivity have long been recognised as processes that need not only biophysical examination, but also socioeconomic understanding (Boardman et al. 2003). These processes relate to topics such as declining food security (Scherr and Yadav 1996), social impacts on poor people (Young 1994), and the increasing costs to agriculture (Pretty et al. 2000). Soil erosion by water and changes in soil quality present substantial threats to the integrity of some lands (Cleaver 1997). In turn, soil erosion is a component of the wider problem of land degradation that is now part of the international campaign for tackling global environmental change. Because of this potential challenge to land resources and to the viability of human societies, soil erosion has been the subject of alarming statistics. For example, the Global Assessment of Land Degradation (GLASOD) project calculates that 22.5% of all productive land has been degraded since 1945 and that the situation is becoming rapidly worse (Oldeman et al. 1990). Soil erosion is the major part of that threat.

Yet, at the same time, few people have a clear idea of the nature and extent of soil erosion and productivity decline. Because there has been so much controversy surrounding the process and its global implications (for example, 'desertification', see Thomas and Middleton 1994), little attention has been paid to the field level and to how farmers perceive the problem. Routinely, farmers describe how soils are getting thinner

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and 'worn out' and how yields are declining. Worldwide, they readily appreciate the problem and the costs that it incurs but often with a very different perception to that of the scientists or professionals who presume to advise them.

This chapter reports on a project to develop and evaluate a set of 'Guidelines' (later published as a 'Handbook') for field assessment of the processes leading to land degradation (Stocking and Murnaghan 2000, 2001, 2003). There are few similar manuals available, the closest in concept to that reported here being Herweg (1996) and Herweg et al. (1999). The project arose from the need expressed by field workers for a readily accessible and practical guide. Traditional techniques have usually involved bounded field plots and measurements of soil loss and runoff into collecting tanks. But these are cumbersome methods, yielding only limited information even after several years of monitoring. So, when undertaking fieldwork with collaborators, most of whom are from (and work in) developing countries, the present author has been on the alert for simple, direct, and useful measures of the dynamics of the processes leading to land degradation. The more one looks, the more is the evidence in the field that has been unseen in the past. The evidence may only amount to small accumulations of soil, or thin layers of residual stones on the surface, both easily overlooked. However, these are 'real' pieces of evidence occurring in actual fields being used by farmers; they represent the outcomes of processes usually instigated by land use practices. So, they have great value – a value that is enhanced by the fact that many measurements can be accomplished much more rapidly than by traditional techniques. Rapid rural appraisal (RRA) and participatory rural appraisal (PRA) have tended to be dominated by social or economic enquiry. This Chapter will present the evidence that change in natural resource quality is also amenable to the benefits of RRA and PRA approaches.

Advantages of a Farmer-perspective Approach

There are three main advantages of adopting a farmer-perspective approach to land degradation assessment. First, measurements are far more realistic of actual field level processes. Secondly, assessments utilise the integrated view of the ultimate client for the work, the farmer. Thirdly, results provide a far more practical view of the types of interventions that might be accepted by land users. To exemplify the various components, Figure 11.1 presents a model of the farmers' domain in relation to the professional perspective with respect to changes in soil productivity and their transmission into policy. If there is to be a policy-relevant outcome, it is essential that items of particular importance to farmers be addressed and then integrated into professional analysis.

Realism

The problem with most techniques of scientific monitoring of erosion processes is that they intervene in the process itself. Measurements may simply reflect the intervention rather than the process in its real field setting. Runoff plot results, for example, are partly a product of creating rigid boundaries and the changes this induces in the erosion process. Even a simple erosion pin (a long thin stake forced into the ground,

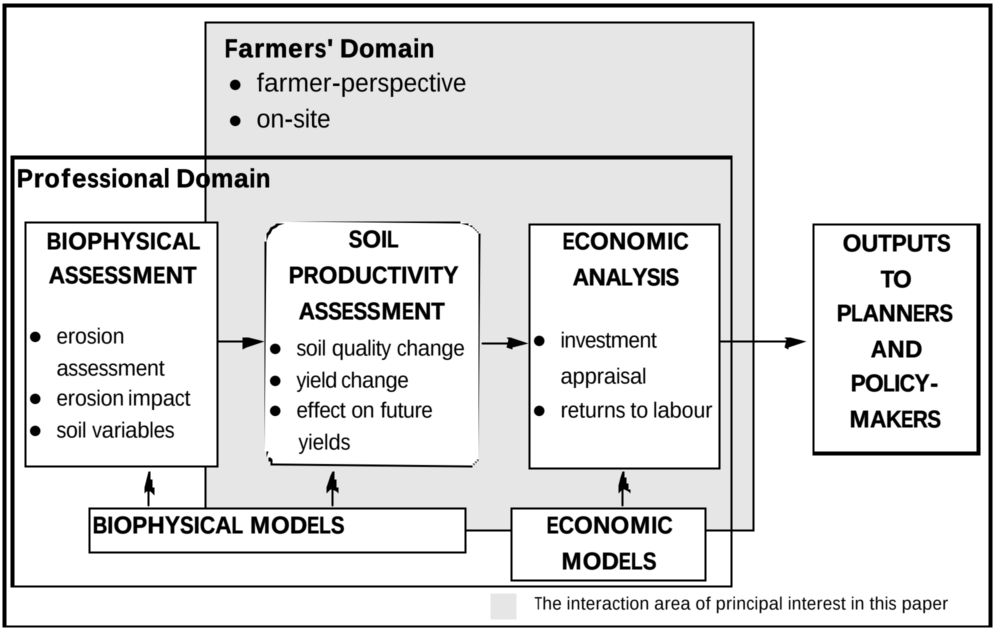

Figure 11.1: **Soil productivity in the context of providing information useful to planning and policy,** Source: Stocking and Clark (1999)

against which lowering of the level of topsoil can be measured) has its problems. The insertion of the stake may crack the soil, altering the local hydrology and resistance to erosion. The stake itself affects runoff around it, possibly causing down-slope eddies in the water current. Stakes are also very likely to be interfered with by small boys and inquisitive cattle. The required accuracy of measurement to 0.1 mm of changes in ground surface is difficult to achieve.

Conversely, most of the field techniques here rely on the results of processes that have not been altered by the technique of monitoring. So, accumulations of sediment against a barrier such as a boundary wall of a field are 'real' accumulations that would have occurred whether or not an observer was trying to measure them. In addition, measuring the height of a mound of soil protected by a tree, relative to the general level of the soil surface influenced by erosion since the tree started to grow, is a 'real' difference that is impossible to ascribe to inaccuracies introduced by the technique of measurement. There may be other explanations for the tree mound but these are no more serious than alternative explanations in other more interventionist techniques. Realism is also enhanced by simple field techniques in that indicators often used by farmers are being employed. The pedestals under small stones and the existence of coarse sand and gravel deposits in fields are both frequently identified by farmers as the result of rain-wash.

Integration

The results derived from field assessments tend to integrate a wide variety of processes of land degradation. This is most evident in changes in soil productivity as measured by farmers' assessments of historical yield. Many scientists may see this as a disadvantage, covering up the causative influences on yield reduction. Yields are a product not only of soil erosion, but also of past and current management, seed sources, climate, pests, and general vagaries of nature. However, land degradation (of which soil erosion is a major process) is a very broad concept, including not only attributes of the physical environment, but also the way in which the environment is managed and how nature reacts to human land use. So, integration is essential if the researcher is to present the outcome of a set of processes that farmers really face. The scientific method of deconstructing natural processes into their singular elements for study and then reassembling them to regain complex reality has dubious validity in ecological systems where it is the interactions between components that are far more influential.

Take the example of how vegetation controls soil erosion. Directly, vegetation introduces organic matter into soil, which renders the soil less erodible. But, indirectly, and of far greater universal importance, is the way that a cover of vegetation intercepts raindrops. The energy of the drops is dissipated in the structure of the plant, rather than being used to dislodge soil particles. These interaction effects are vital to capture if accurate assessment of the severity of erosion is to be made.

Practicality

Probably the most important criterion is that farmer-perspective assessments are more practical. They bring together the long experience of the farmer in using the field and of noting what happens – experience that could not possibly have been accumulated by the researcher as an occasional visitor. The researcher can also learn much about how farmers respond to the effects of land degradation from in-field experimentation by farmers. Farmers experiment in many aspects – they try new varieties, vary planting dates, and test different fertility treatments and conservation measures.

Practicality also extends to the application and use of the results. If, for example, the farmer has been involved in collection and processing of field data on soil erosion and its impact on productivity, then ownership of the results is far more clearly identified with the farmer than the researcher. A condition for this to work, however, is the willingness and responsiveness of the researcher to allow the land user to take the lead in the participatory process. This participatory element has been found to be essential in most rural development work. Furthermore, results of such assessments will be much more relevant to the issues facing land users. Change in soil-productivity that affects future yields is a constant concern to many marginal land users. So, assessments that use yield as the indicator variable will much more closely relate to farmers' priorities and be much more likely to induce solutions that combat soil erosion through yield-enhancing measures.

A further practical attribute of field-level farmer-perspective assessments is that they are quick and simple. Many more observations can be accomplished in a short-time than through the more complex procedures of standard monitoring. Having the possibility of multiple data points enables a much better sampling of the enormous number of permutations of field types, management regimes, crops, and land uses. The number of permutations is a real problematic issue for researcher-centred methods. Standard empirical approaches, such as experimental plots, cannot possibly cope with the range of crops, management methods, and soil types with which farmers have to deal. They deal with ‘snapshots’ and very limited sampling of the conditions, hoping that in some way the sample might be representative. They look for homogeneous units, into which experimental results might be applied, while acknowledging that such units are imposed by the researcher onto real-life variability. By the time the results are processed, conditions may well have changed – a new variety, adopted management techniques, and altered market prices, for example. All these will affect the viability of farming and may not be reflected in empirical analysis. Farmer-centred methods should alternatively examine the factors that determine variability and decision taking in heterogeneous environments where predictability is uncertain. Using field assessments ensures a better focus on the issues important to farmers.

Lest it be thought that field assessments are only advantageous, it must be stressed that they do have some limitations. Absolute accuracy can be compromised because field instruments such as a ruler marked in millimetres cannot identify small changes. However, this failing can be compensated for by taking many measurements, certainly many more than would be available by standard techniques. In addition, because farmer-perspective assessments tend to integrate the effect of a variety of often-unknown processes, it is very difficult to extrapolate the results to unmeasured conditions. If, for example, it were known that aluminium toxicity causes yield declines after a crop that allows high erosion, then these same conditions would likely prevail at another broadly similar geographical location. But farmer-perspective assessments usually contain only limited information on causative relationships. Furthermore, it has been claimed that farmer-perspective assessments are less reliable. It is true that many means of controlling reliability are unavailable to the researcher. How does one know the farmer is telling the truth, for example? Different methods give different representations of absolute levels of soil erosion.

Because of space limitations in this chapter, only one example of a field assessment technique is given here. The interested reader is referred to the ‘Handbook’ for more techniques, as well as ways of combining indicators to derive more robust conclusions as to the status of land degradation (Stocking and Murnaghan 2001, 2003 [in Spanish]).

Field Technique Example: Soil Loss Indicator

Land degradation, including soil erosion, encompasses a vast array of biophysical and socioeconomic processes, which make its assessment difficult to encapsulate in a few simple measures. It occurs over a variety of time-scales, from a single storm to many decades. It happens over many spatial scales, from the site of impact of a single raindrop through to whole fields and catchments. Without extreme care, measurements undertaken at one set of scales cannot be compared with measurements at another.

This is why field assessments should use indicators that do the following.

- Capture time-scales that have significance for the farmer, usually from one growing season through to four or five years. Some land users do have concerns for long-term sustainability, provided that immediate food needs are assured.
- Focus on the concerns of land users, primarily the way that land degradation makes farming more difficult and the impact of degradation on productivity.
- Concentrate on relatively simple measurements, some of which may be quantified into absolute rates of soil loss, but none of which should be taken in isolation. Farmers themselves use indicators such as soil depth and evenness of the standing crop.

A summary list of erosion and productivity indicators is given in Table 11.1. The example chosen here is the 'armour layer technique' (see Box 11.1). An armour layer is the concentration, at the soil surface, of coarser soil particles that would ordinarily be randomly distributed throughout the topsoil. Such a concentration of coarse material usually indicates that finer soil particles have been selectively removed by erosion. Farmers commonly remark how they have to dig in this coarse material when preparing the land for planting.

In the example described in Box 11.1, an average armour layer depth of 1 mm, where the fraction of coarse particles in the original soil is 20%, gives a calculated erosion rate of 52 t/ha. From the farmer, the field assessor can determine the length of time the soil has been undisturbed, so deriving a short-term soil loss rate.

Conclusions

Field assessment techniques have considerable advantages over standard experimental approaches to measuring soil loss and changes in soil quality. They enable a much closer record of processes that are actually happening in the field, because they do not create the sort of disturbance and interference to biophysical changes that occur when bounded plots or laboratory samples are taken. They also allow a much closer involvement of farmers and local communities, to the extent that field assessment techniques could be described as giving a more clearly focused farmer perspective. If conservation professionals want their recommended technologies to become accepted by farmers, then this perspective of land users is essential to obtain.

The approach adopted in this chapter is recommended to those who, without any need for natural science training, wish to assess soil erosion rapidly in the field in partnership with farmers and land users. The purpose of such assessment, as illustrated in Figure 11.1, is to link with economic/financial analysis and to provide policy-relevant experiences for the future sustainability of land resources. Of course, the steps from economic analysis towards policy-relevant analysis are themselves fraught with difficulty. However, with a strongly farmer-centred assessment of soil erosion and impact on productivity, the opportunity to develop improved contributions to policy must be greatly enhanced.

Table 11.1: **Field techniques for erosion rate and impact assessment: examples drawn from field work in Tanzania, Sri Lanka, and Bolivia**

Measurement	Technique	Observations	Perceived by farmers?
Short- (up to one year) and medium- (2-5 years) term net soil loss	(1) Erosion pins (2) Rainfall simulation from bounded plot (3) Stone pedestals (4) Grass/herb pedestals (5) Armour layer (6) Sediment in drains (7) Volume of in-field rills	(1) Micrometer gauge; problems over site selection, accuracy, and pins being stolen (2) Artificial site and rainfall conditions (3) Need to know length of time soil is undisturbed (4) Difficult to interpret (5) Need stones in soil (6) Often only coarse material; fines completely removed (7) May miss sheet erosion	(1) No – lowering of surface rarely perceived (2) No – artificial (3) No – not seen (4) Sometimes observed and described (5) Rarely (6) Yes – seen by farmers (7) Sometimes described
Long-term (more than 5 years) net soil loss	(8) Tree mounds (9) Topsoil depth	(8) Prone to exaggerated rates (9) Useful for comparative view of similar positions on catena	(8) No – not described (9) Yes – common impact mentioned by many and related to crop growth
Sediment movement down slope	(10) Gerlach troughs (11) Semi-circular sediment traps – plastic lined	(10) Problems over site selection and size of sampling bottle (11) Prone to damage by cattle	(10) No – sediment wash across slopes rarely seen (11) as 10
Mean annual soil loss (over more than 10 years)	(12) Erosion prediction models (USLE; SLEMSA, Eurosem etc)	(12) Not really a field technique. Model variables may require field observation and, most importantly, local validation	(12) Definitely no
Gully erosion	(13) Markers and gully profiles (14) Time-series aerial photos	(13) and (14) Process highly discontinuous in space and time; best assessed over longer term and often available for 30+ years from local people and photos	(13) and (14) Gullies widely described as problematic; observation on past gully positions and loss of fields, roads etc.
Impact on soil quality	(15) Soil depth – erosion phases (16) Comparison of clays and organic matter in sediment with topsoil (17) Soil colour comparison	(15) Long-term historical erosion; may also include natural colluvial process (16) A field method of determining enrichment ratio (17) For each soil type, Munsell colour can be related to nutrient content	(15) Yes – often mentioned (16) Possibly – but little evidence to date (17) Yes – in many indigenous classifications, but not necessarily related to erosion
Impact on yields	(18) Observations of plant growth with soil depth (19) Farmers' assessments of yield variations	(18) Difficult choice of variables: height, cover, tillers, flowers – needs validation and relating to yields (19) Drawing of size of crops from different fields found useful	(18) Yes – widely seen as important and related to harvesting and crop prices (19) Yes – often mentioned and perceived

Source: Stocking and Clark (1999)

BOX 11.1: **The Armour Layer Technique**

An armour layer forms where raindrops or the power of the wind detach finer particles, leaving behind a coarse residue of stones, resistant aggregates (such as lumps of ferricrete), and sand. It is most likely to form on soils that have both a stony and coarse fraction as well as a fine clay to silt fraction.

Field measurement consists of digging a small hole to reveal the undisturbed armour layer. Using a ruler, the depth of the coarse top layer is measured (see Figures 11.2 and 11.3). Where the depth of the armour layer is less than 1 mm, it is best to scrape the stones from a small area of about three times the size and then measure this depth and divide by three. This helps to reduce the inaccuracies in trying to measure very small depths of stones. Several measurements at different places in the field should be made in order to calculate the average depth of the armour layer. The approximate proportion of stones and coarse particles in the topsoil below the armour layer is then judged by taking a handful of topsoil from below the armour layer and separating the coarse particles from the rest of the soil. In the palm of the hand, an estimate is made of the percentage of coarse particles in the original soil. Again, this estimation should be repeated at different points in the field. The depth of the armour layer is then compared to the amount of topsoil that would have contained that quantity of coarse material. The amount of finer soil particles that has been lost through erosion can then be estimated. These calculations tell us the amount of fine particles that has been lost since the soil was last disturbed, for example since it was tilled or weeded.

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Figure 11.2: **Measuring an armour layer in the field with farmer and researcher**

Figure 11.3: **Detailed view of assessment of depth of armour layer**

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