

## CHAPTER 7: CONSEQUENCES OF LAND DEGRADATION FOR LAND USERS

### 7.1 A Game of Winners and Losers

Often land degradation is perceived as having only negative effects for land users and society alike. These effects are far-reaching with off-site costs (referred to in Chapter 2) extending well beyond the site where land degradation has occurred. The effects of land degradation may be experienced by future generations, affecting how they can use the land. Box 7.1 lists some actors typically affected by land degradation.

#### **Box 7.1: Who is Affected by Land Degradation?**

- the user of degraded land, through loss of current production and more difficult farming operations;
- the person who uses the piece of land immediately downhill from the degraded site may face landslides or floods, even though their land may not itself be degraded directly by its user;
- the organisation that supervises the hydro-electric dam that becomes sedimented loses by land degradation;
- the port authority that has to pay for dredging channels for ships and the water authority that has to install expensive purification works;
- the national economy may lose through collecting fewer tax revenues from land users, and by a decrease in the value of the stock of natural resources.

However, this does not disclose the full picture. A cynic might say that "land degradation is a game of winners and losers". There is an important grain of truth here: some people do gain from land degradation, while others lose. It is a fact, unpalatable to many, that land degradation can bring decided advantage to some people some of the time. If land degradation were only negative all the time, and if it were to mean that consistently everyone loses cash and resources, then undoubtedly society would have derived successful ways to combat it. Thus, it is important that the field assessor is alert to the potential gains that may accrue to some parties as a result of land degradation, as this is critical to an understanding of the attitudes of land users to land degradation. The field assessor should try to gain a clear picture, preferably in

quantitative terms, of how the various actors may derive costs or benefits from the continuation of land degradation, and costs or benefits from the control of land degradation. Such an understanding is key to the design of sustainable programmes of rehabilitation, which will be the subject of the final chapter (8) of these *Guidelines*.

So, who has a stake in land degradation continuing, or at least who would suffer some disadvantage if more effort were put into land degradation control? Although it is impossible to generalise, and each case presents unique combinations of actors and biophysical processes, the 'winners', those who gain from land degradation, can be drawn from the same categories of people as those who lose as a result of land degradation. Examples of possible winners include:

#### • **Immediate land users**

at the site of the degradation: if land users were to have to spend more money to control the land degradation than they would gain in the consequent increase in production, then they would, on balance, be winners in allowing land degradation to continue.



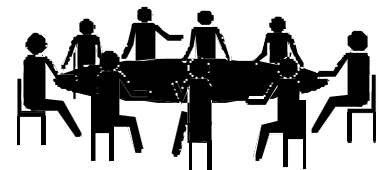
#### • **Downstream land users:**

if they gain rich eroded sediments from uphill, then the productive value of the land would similarly gain.



#### • **Authorities**

responsible for dealing with the impacts of land



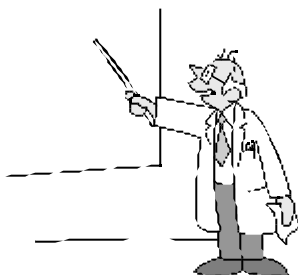
degradation: in a perverse way, land degradation can increase their power and importance. If, say, electricity supply were interrupted because of damaged hydro-

electric installations or sedimented waterways, the authorities may claim powers to evict upstream land users and alienate land for forestry over which the authority may gain production benefits.

- **Governments:** many, if not most, developing country governments are maintained in power by the poor rural peasantry. Their chief opposition tends to come from urban elites. Keeping the peasantry poor on degraded land can mean political advantage and continuation in power. Diverting resources from agriculture to keeping the urban masses contented is another way of **not** controlling land degradation which may help keep the more volatile political ambitions of urban people in check.



- **Scientists and professionals:** if it were not for land degradation, this book would not have been written and we would have less to do!



**Figure 7.1: Paddy Fields, Sri Lanka**

These rice fields were made from soil eroded uphill, and they are recharged with nutrients after every large storm event, to the detriment of the soils above.

Land degradation is by definition (see Chapter 2) the **aggregate** diminution of the productive potential of the land. Society as a whole loses, but within that aggregate loss, it has to be

recognised that some people gain. That recognition is essential in order to appreciate the appropriate points of intervention in land degradation control and to consider those persons who would lose if land degradation were to be controlled<sup>1</sup>. However, the focus of these *Guidelines* is on a farmer-perspective, and so it is the analysis of field indicators within a framework of the consequences of land degradation for the immediate land users of the degraded land that is discussed in the following sections.

## 7.2 Outcomes of Land Degradation

One of the best-researched areas of land degradation outcomes for land users is in the impact of soil erosion on yields of crops – called erosion-induced loss in soil productivity. By combining indicators of both the *process* of degradation and its *impact*, the field assessor can develop scenario outcomes. Before describing how to develop such scenarios, an understanding needs to be gained of the principal variables involved.

For erosion-induced loss in soil productivity, there are three major variables:

- **soil erosion** – represented as a *cumulative amount* of soil lost; that is, as soil loss over a unit of land area accumulated over specified periods of time. This can be expressed as a *rate* of soil loss (e.g. tonnes/ha/yr) or as a *cumulative amount* for a longer time period such as 20 years (e.g. tonnes/ha over 20 years).
- **time** – the length of time over which soil loss and declining yields are measured, and the time over which scenarios are constructed (usually 20 years or more).
- **crop yield** – represented as yield of a major crop, such as maize over one growing season (e.g. kg/ha).

There are three pair-wise permutations of these three variables: erosion-time; erosion-yield;

<sup>1</sup> Further analysis of these matters is outside the scope of these *Guidelines*. The reader is referred to texts in the broad field of political economy of natural resources, such as Blaikie and Brookfield's *Land Degradation and Society* (see Bibliography).

yield-time. Each permutation gives us interesting insights as to the outcome of land degradation and the effects this has on land users (see Section 7.3 below). The terms *resilience* and *sensitivity* introduced in Section 2.4 enable description to be made of the status of the land and its potential for dynamic change and effect on land users. Take some possibilities relating *erosion rate* (erosion-time) and *impact* (yield), and compare these with Table 2.2, the sensitivity-resilience matrix for land degradation<sup>2</sup>:

- (1) There is little soil erosion, and what little there is has almost no effect on yields – low sensitivity and probably high resilience, if restoration of yields is easy.
- (2) There is little soil erosion, but what little there is has a large impact on yields – low sensitivity and low resilience, if yield restoration is difficult
- (3) There is much soil erosion, but there is little impact on yields – high sensitivity and high resilience.
- (4) There is much soil erosion, and a large impact on yields – high sensitivity and low resilience.

Obviously there is a continuum between these four states with the majority of cases occurring somewhere between high/low resilience and sensitivity. They do mean for the land user that very different land use and conservation practices present themselves as being rational.

These observations are only snapshots of the sort of outcomes that could be predicted in determining the consequences of land degradation for the land user. They bring in additional variables, which the field assessor can determine, such as:

- inherent soil fertility: it makes a lot of difference to many outcomes, whether a soil starts in good condition (then it may well be worth expending effort to keep it good) or in poor condition (where effort may have no discernible return in improving the soil or giving better yields).

<sup>2</sup> This sensitivity-resilience matrix is further developed in Chapter 8 in order to express how the outcomes for land users can be developed into conservation interventions. This is based upon the understanding of how easy it is to degrade the land and how easy it is to restore—see Table 8.1.

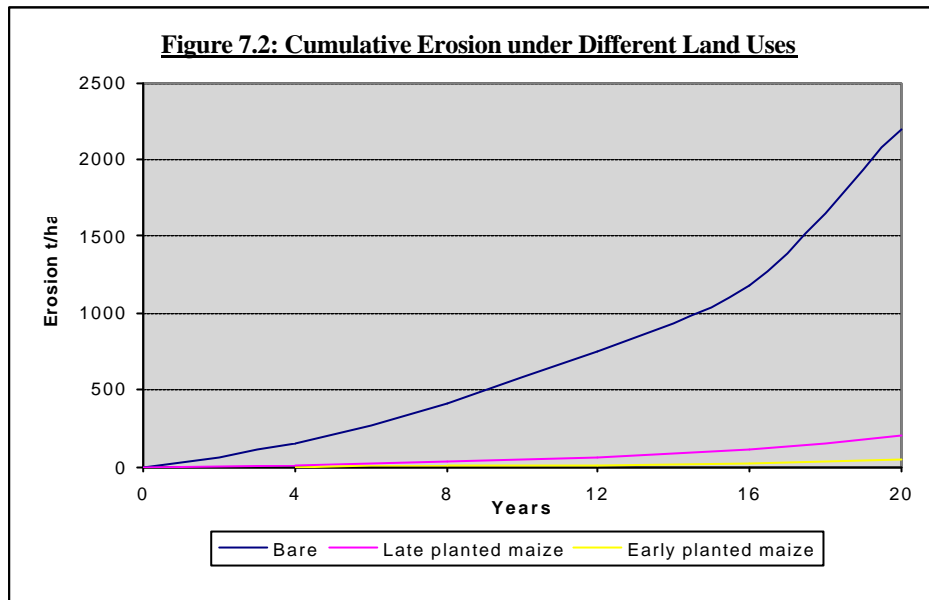
- resource endowments of the land user: this is a complicated subject, but to demonstrate simply consider two farmers, one with a little land, the other with a lot. The land-poor farmer will need to retain the quality of the land, if this is the only source of income, usually by intensifying production. The land-rich farmer can switch production to other fields, leaving the eroded land to regain fertility through fallowing. This is a case where poor farmers perhaps best serve conservation. The very opposite may pertain for resource endowments in capital. The rich farmer can afford to implement physical conservation measures, by hiring labour and equipment; the poor cannot.

### 7.3 Constructing Scenarios – Theoretical Perspectives

The three outcome permutations of erosion-induced loss in soil productivity are considered here in turn. Each of the following three subsections illustrates theoretically how scenario predictions can be derived from typical data sets that could be gained by field assessment. (The results that illustrate them in the graphs come from recent work completed for the UN Food and Agriculture Organization for food security in Africa - see Bibliography.) The practical ways in which these relationships could be developed are considered in Section 7.4.

#### Erosion-time

A typical set of erosion-time relationships for different land uses is given in Figure 7.2, derived from Zimbabwean data. At a broad level of analysis, it can be seen clearly how the extreme curves (for bare soil and early-planted maize) progressively diverge over time. For the field analyst this is useful, because it shows over time how much soil is 'saved' by the maize that gives the best cover. Indeed, the *rate* of divergence progressively increases as the bare soil gets more and more degraded. This is a common phenomenon on most soils, that degraded conditions lead to even more degradation, while land use that has biological forms of conservation tends to become more

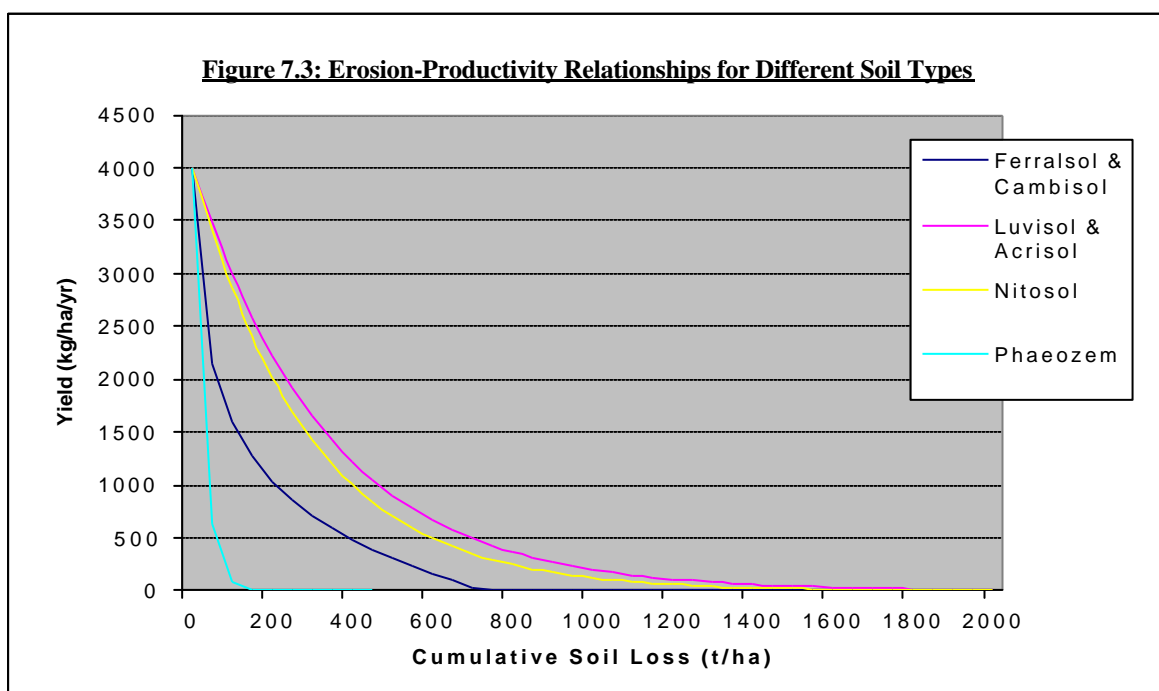


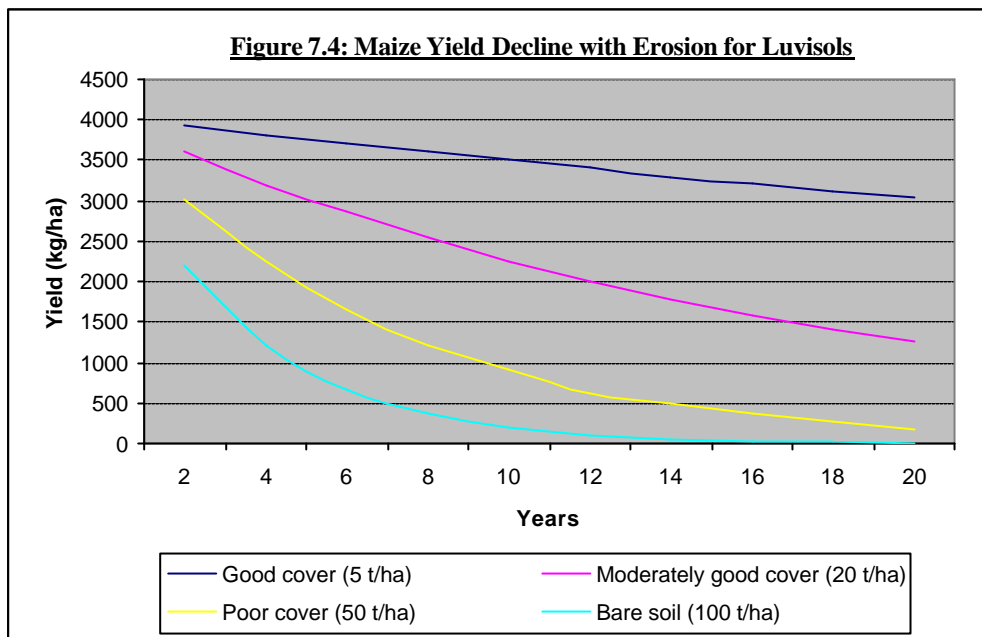
resilient as organic matter levels increase. It is these sort of changes and the dynamic interactions with land use that are so critical to both the farmer and the field assessor of land degradation.

### Erosion-yield

Figure 7.3 shows the way in which yields decline with cumulative soil loss – the sort of soil loss that could accumulate over a number of years depending upon the rate of land degradation. The least resilient soil, the Phaeozem, has the sharpest decline in yields. This means that per unit of soil loss, the greatest impact of erosion is with this relatively

productive soil. On the other hand, a Phaeozem is not especially sensitive – it does not erode easily. It would be worthwhile for the land user to concentrate efforts on preventing erosion with this soil, because in this way maximum yields can be 'saved' and a good soil retained in reasonable condition. The opposite is true of Ferralsols – they do erode easily (that is, they are sensitive), but per unit of soil loss, this has modest impact (they are resilient). For the land user, this means that it may not be worth worrying too much about land degradation, because only when erosion becomes very severe is there a substantial impact on yields.





### Yield-time

Figure 7.4 demonstrates for a Luvisol how different standards of management, as assessed by degree of plant cover, affect yield-time scenarios. The Luvisol is one of the most strongly differentiated soils in this respect – good management as represented by good cover can keep yields continuously high, while poor management as represented by bare soil lets the yields crash. Again, the implications for land users may be drawn. Indeed, the aspect of time is very useful because it relates directly to the concerns of a farmer.

The yield-time scenario may be interrogated to ask "how long can I use this soil (or piece of

land) before yields decline to a level where it is not worth my continuing?" Table 7.1 gives soil-life spans for some South American sites. The implications of the years of useful life of the soil are potentially huge for the land user. For the Ferralsol and Acrisol, it makes little difference – however, the soil is managed, degradation will mean that it will never be usable economically for more than 4 years continuously. On the other hand, a Cambisol and Phaeozem can be used even to moderate levels of management for a generation or more. The Nitosol by contrast is absolutely and robustly sustainable provided that management is consistently good – otherwise, after only a few years the yields decline to such an extent it is not worth using any more.

**Table 7.1: Years Taken for Different Soils to Reach a Critical Yield Level of 1000 kg/ha/yr with Continued Erosion.**

Management level	Ferralsol	Acrisol	Luvisol	Phaeozem	Cambisol	Nitosol
Good cover	3	4	93	200	210	950
Moderate cover	2	3	23	65	42	19
Poor cover	1	2	9	7	23	4
Bare soil	1	1	5	3	9	3

**Box 7.2: Gaining a Farmer-Perspective I**



Sitting with the farmer – do not stand over him or her. (Example from Bolivia.)



Use small focus groups of farmers and set up discussions on why and how they feel their land is degrading – an example in Mexico

***7.4 Constructing Scenarios – Practical Issues***

As noted already, these are complex scenarios. The outcomes of land degradation involve many factors, only some of which are directly measurable, but even these require repeated measurements over many years in order to construct reliable relationships with land degradation. Consequently, scenarios constructed by the field assessor from field measurements and discussions with land users will represent best estimates. Nevertheless, isolating erosion-yield-time relationships is an excellent way of bringing together the outcomes of greatest importance from a farmer-perspective. So, it is worth the effort, even if estimates or guesses must be made to fill in missing items of data. These estimates or guesses must, of course, be given prominent 'health warnings' (see Section 1.3 of these *Guidelines*).

**STEP 1 – Targeting time-series sources of information**

The objective of time series data should be to develop a database of qualitative and quantitative changes in land degradation and associated factors. These factors should be both causative (e.g. major floods) and impact-related (e.g. triggering migration).



**Table 7.2: Time-series Data**

<i>Source</i>	<i>Data Type</i>
Farmer	Records of yields, knowledge as to how things have changed in the field and the farmer's response to these changes. It is good to develop a time-line of land use and practice for a field, starting from when it was originally opened up for land use.
In-field	Observations of erosion rate indicators for different time periods (see Chapter 4). Longer-term indicators such as build-up of sediment behind boundaries, the past position of gully heads or the development of tree mounds are especially useful. Farmers' knowledge is again valuable.
Community	Observations of major changes and events, such as droughts, famines, migrations (and other population movements). Whilst not directly quantifiable, such evidence supplements and may verify field evidence of change.
Official records	Delivery of crops to market, purchase of fertilisers, field inspections.

## STEP 2 Plotting yield-impact data over time



The objective here is to develop a curve of yield over time. Both the starting yield and the current yield are important. The first is a reflection of what the yield would have been on first opening up the land. It is best to try to isolate the effect of fertilisers by considering only yields at low-input levels.

Sources of information on yield impact include the following:

- From time-series data above, trends in yields should be plotted. Land degradation is, however, only one element in changing production. Fertilizers or new crop varieties can mask the effect of land degradation.
- *In situ* yield differences, using soil variables as a proxy for time. An example of this is to measure the differences in yield between a degraded and a non-degraded field; or a part of the field where erosion has reduced the depth of topsoil and another part where accumulation has occurred. In both cases, soil depth or other soil variable acts as a surrogate measure of land degradation over time.
- Using soil variables such as depth, develop a spatial database of current crop yields over the fields being surveyed and compare these with actual yields reported by the farmer or directly measured.

## STEP 3 Bringing in supplementary information

The most common and probably the most useful supplementary information is obtained from soil loss and yield impact models. *These should never be seen as verifiable sources of information* – model outputs are only as accurate as the quality of the data that went into them. Taking data from one place to very different conditions of soil, climate, slope and land use has been shown to lead to enormous errors. Nevertheless, with care, models can give useful supporting data,



### Box 7.3: Gaining a Farmer-Perspective II



Going out in the rain – these professionals in Sri Lanka had never seen land degradation processes in action before.



Getting down to actual processes with the farmer showing what he has seen – example from Bolivia

especially if the outputs of the models are calibrated and verified with actual field data. It is outside the scope of these *Guidelines* to detail the available models and to show their application. Other manuals exist that do this. Models used to predict soil loss and yield impact include:

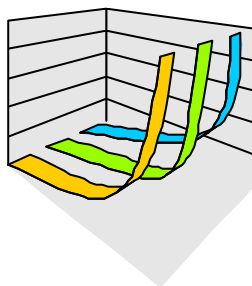
- USLE – Universal Soil Loss Equation: a wholly parametric model that has been used by the US Natural Resources Conservation Service for many years. It works poorly as an *absolute* predictor of soil loss for tropical conditions. However, model predictions of soil loss are usually in the correct rank order, and so it can be used to show what land uses are more hazardous to land degradation than others.
- SLEMSA – Soil Loss Estimation Model for Southern Africa, developed in Zimbabwe as a lower cost alternative to USLE,

requiring fewer data. Because it is derived from sub-tropical conditions, SLEMSA seems to have better predictive capability than the USLE for steep lands and tropical soils. But again, care needs to be exercised in using the model outputs as absolute predictions.

- PI – Productivity Index. This is a fairly simple model based upon a very limited range of soil variables such as soil depth, which plots yield changes on the assumption that a single variable will usually be the single most limiting factor.
- EPIC – Erosion-Productivity Impact Calculator. This US model is essentially a USLE extension into productivity, involving a large number of sub-models. Unless EPIC has been developed and verified for the particular area being surveyed for land degradation, the amount of effort required to make it work is unlikely to be rewarded with usable results.

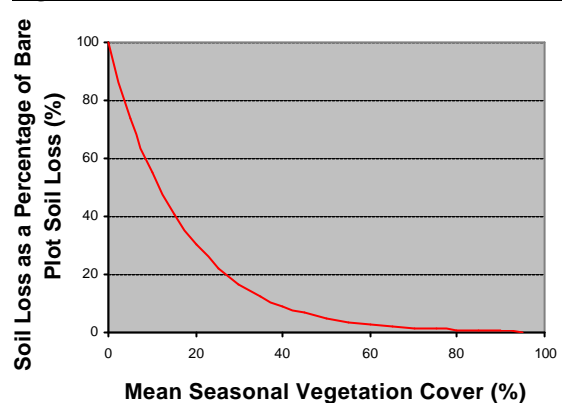
#### STEP 4 Constructing erosion-yield-time curves

The three pair-wise permutations of erosion, yield and time each have their main functions and uses. It is suggested that single data point plots are plotted on three graphs. Approximate lines can then be interpolated on the basis that:



- land degradation tends to plot to an exponential function. In other words, as land becomes more degraded, its rate of degradation increases. (See Figure 7.2)
- the difference between land uses can be assigned according to a cover curve (Figure 7.5), which expresses the proportional change in erosion consequent upon a change in mean vegetation cover (see Bibliography, Lal, 1994). So, if a land use has a mean vegetation cover that gives an erosion percentage of 1% (i.e. 1% of the erosion that would have occurred if the land had been bare), while another land use has a percentage of 30%, then the second land use has 30 times the erosion of the first.

**Figure 7.5: Generalised Erosion-Cover Relationship**



In the final analysis, these scenarios are merely forums for bringing together diverse sources of data into a form that has meaning both to the land user and the professional. The ultimate objective is always to gain a realistic assessment of the consequences of land degradation to land users. If land degradation is truly a game of winners and losers, the field assessor does obviously need to concentrate on the losers. The loser is more likely to be the marginal person in society, as well as the land user living on the most difficult parts of the landscape such as steep slopes and erodible soils. However, as this chapter has highlighted, the field assessor needs to keep an analytical eye on the winners – the people who have everything to gain from degradation continuing. If, unlike the losers, the winners are the more privileged in society, they are more able to keep the *status quo* and ensure that land degradation control measures are ineffective.

In the final chapter of these *Guidelines*, the information so far gained is used to examine and analyse the potential benefits of the reverse side of the 'land degradation coin' – conservation and rehabilitation.

