CHAPTER 2: WHAT IS LAND DEGRADATION?

2.1 Definition

Land degradation is a composite term; it has no single readily-identifiable feature, but instead describes how one or more of the land resources (soil, water, vegetation, rocks, air, climate, relief) has changed for the worse. A landslide is often viewed as an example of land degradation in action – it changes the features of the land, causes destruction of houses, and disrupts activities. In the longer term, however, the area of a landslide may regain its productivity. In places such as Jamaica and Papua New Guinea, old landslide scars are noted for supporting better crops and more intensive agricultural possibilities than on the adjacent land not affected by landslides especially when the new soil is derived from less weathered rock materials, such as calcareous mudstones. So, land degradation is far from being a simple process, with clear outcomes. This complexity needs to be appreciated by the field assessor, before any attempt is made either to define land degradation or to measure it.

Land degradation generally signifies the temporary or permanent decline in the productive capacity of the land (UN/FAO definition). Another definition describes it as, "the aggregate diminution of the productive potential of the land, including its major uses (rain-fed, arable, irrigated, rangeland, forest), its farming systems (e.g. smallholder subsistence) and its value as an economic resource." This link between degradation (which is often caused by land use practices) and its effect on land use is central to nearly all published definitions of land degradation. The emphasis on land, rather than soil, broadens the focus to include natural resources, such as climate, water, landforms and vegetation. The productivity of grassland and forest resources, in addition to that of cropland, is embodied in this definition. Other definitions differentiate between reversible and irreversible land degradation. While the terms are used here, the degree of reversibility is not a particularly useful measure – given sufficient time all degradation can be reversed, as illustrated by the landslide example above. So, reversibility depends upon whose perspective is being assessed and what timescale is envisaged. Whilst soil degradation is recognised as a major aspect of land degradation, other processes which affect the productive capacity of cropland, rangeland and forests, such as lowering of the water table and deforestation, are captured by the concept of land degradation.

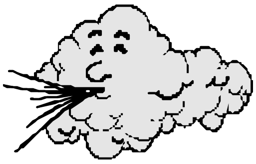
Land degradation is, however, difficult to grasp in its totality. The "productive capacity of land" cannot be assessed simply by any single measure. Therefore, we have to use indicators of land degradation. Indicators are variables which may show that land degradation has taken place – they are not necessarily the actual degradation itself. The piling up of sediment against a downslope barrier may be an 'indicator' that land degradation is occurring upslope. Similarly, decline in yields of a crop may be an indicator that soil quality has changed, which in turn may indicate that soil and land degradation are also occurring. The condition of the soil is one of the best indicators of land degradation. The soil integrates a variety of important processes involving vegetation growth, overland flow of water, infiltration, land use and land management. Soil degradation is, in itself, an indicator of land degradation. But, in the field, further variables are used as indicators of the occurrence of soil degradation. This chapter and much of the rest of these *Guidelines* will, therefore, dwell primarily on the use of evidence from the soil (mainly soil degradation) and from plants growing on the soil (soil productivity).

Types of soil degradation include:

1) <u>Soil erosion by water:</u> the removal of soil particles by the action of water. Usually seen as sheet erosion (a more or less uniform removal of a thin layer of topsoil), rill erosion (small channels in the

field) or gully erosion (large channels, similar to incised rivers). One important feature of soil erosion by water is the selective removal of the finer and more fertile fraction of the soil.

2) Soil erosion by wind: the removal of soil particles by wind action. Usually this is sheet erosion, where soil is removed in thin layers, but sometimes the effect of the wind can carve out hollows and other features. Wind erosion most easily occurs with fine to medium size sand particles.



3) Soil fertility decline: the degradation of soil physical, biological and chemical properties. Erosion leads to reduced soil productivity, as do:
   a) Reduction in soil organic matter, with associated decline in soil biological activity;
   b) Degradation of soil physical properties as a result of reduced organic matter (structure, aeration and water-holding capacity may be affected);
   c) Changes in soil nutrient content leading to deficiencies, or toxic levels, of nutrients essential for healthy plant growth;
   d) Build up of toxic substances – e.g. pollution, incorrect application of fertilisers.
4) Waterlogging: caused by a rise in groundwater close to the soil surface or inadequate drainage of surface water, often resulting from poor irrigation management. As a result of waterlogging, water saturates the root zone leading to oxygen deficiency.
5) Increase in salts: this could either be salinization, an increase in salt in the soil water solution, or sodication, an increase of sodium cations (Na^+) on the soil particles. Salinization often occurs in conjunction with poor irrigation management. Mostly, sodication tends to occur naturally. Areas where the water table fluctuates may be prone to sodication.
6) Sedimentation or 'soil burial': this may occur through flooding, where fertile soil is buried under less fertile sediments; or wind blows, where sand inundates grazing lands; or catastrophic events such as volcanic eruptions.

In addition to these principal types of soil degradation, other common types of land degradation include:

7) Lowering of the water table: this usually occurs where extraction of groundwater has exceeded the natural recharge capacity of the water table.
8) Loss of vegetation cover: vegetation is important in many ways. It protects the soil from erosion by wind and water and it provides organic material to maintain levels of nutrients essential for healthy plant growth. Plant roots help to maintain soil structure and facilitate water infiltration.
9) Increased stoniness and rock cover of the land: this would usually be associated with extreme levels of soil erosion causing exhumation of stones and rock.

Figure 2.1: Eroded Wastelands in Rajasthan, India
(Note the stony surface which may indicate that finer soil particles have been removed by the action of wind or water.)

Figure 2.2: Erosion under Cotton Plants, Ghana
(Cotton is slow growing, and even when fully mature, it provides very little vegetative cover. Thus, little protection is afforded to the soil surface against wind and water erosion.)

Although the foregoing list neatly breaks down the components of soil degradation by cause, very often these agents of degradation act together. For example, strong winds often occur at the front of a storm, thus wind erosion and water erosion may result from the same event. Additionally, a soil that has suffered some form of degradation may be more likely to be further degraded than another soil similar in all respects except for the level of degradation. One well-accepted indicator of increased erodibility is the level of soil organic matter. Where the organic matter content of a soil falls below 2% the soil is more prone to erosion, because soil aggregates are less strong and individual particles are more likely to be dislodged.

Figure 2.3: Eroded 'Badlands': Sodic Soils, Bolivia

Figure 2.4: Tree Root Exposure as a Result of Soil Loss from Steep Slopes, Sri Lanka

Figure 2.5: Land cleared using Fire for Conversion to Agricultural Use, Papua New Guinea

Some environments are naturally more at risk to land degradation than others. Factors such as steep slopes, high intensity rainfall and soil organic matter influence the likelihood of the occurrence of degradation. Identification of these factors allows land users to implement

Box 2.1: 'At-Risk Environments' – Flood-Prone Areas in Peru

Land degradation occurs under a wide variety of conditions and circumstances. Nevertheless, some environments are more at risk of degradation. This risk of degradation affects how people manage their biophysical environment but also how their environment affects them. A good example comes from the PLEC sites in the Peruvian Amazon, which are subject to two different types of flooding.

The first occurs in coastal regions as a result of inundations from the sea. The second type of flooding is the annual increase in river levels in Amazonia which results in flooding of the land along the riverbanks. Much of the agricultural production in Peruvian Amazonia takes place along the riverbanks where the level of soil fertility is very high. Such annual flooding is part of the agricultural cycle and, as such, is planned for by local people.

The flood level is critical in determining the effect of flooding. Exceptionally high flood levels can lead to reduced pest and weed levels, improved hunting and better fishing in the next year, but if the higher areas are also flooded, crops may be destroyed and food scarcity may ensue. Very high levels of sedimentation, particularly of sand, can change the landscape completely. Fast flowing floods may result in severe riverbank erosion and the loss of valuable agricultural land close to the river. On the other hand, when the flood level is low the staple crops grown in the relatively high areas are not endangered but pests survive and, if there is little sedimentation, fertility replenishment may be poor.

Source: Miguel Pinedo, PLEC-Peru Cluster Leader, personal correspondence.

techniques that safeguard against loss of productivity. Management practices also exert a significant influence on the susceptibility of a landscape to degradation. Extensive and poorly managed land use systems are more likely to degrade than intensive, intricately-managed plots.

Milder forms of land degradation can be reversed by changes in land management techniques, but more serious forms of degradation may be extremely expensive to reverse (such as salinity) or may be, for practical purposes, irreversible. Soil erosion, when serious and prolonged, is effectively irreversible because, in most circumstances, the rate of soil formation is so slow. In moist, warm climates formation of just a few centimetres of soil may take thousands of years and in cold, dry climates it can take even longer. Soil loss through erosion happens far faster: up to 300 times faster where the ground is bare.

Soil erosion is the most widely recognised and most common form of land degradation and, therefore, a major cause of falling productivity. However, since the effects of soil loss vary depending on the underlying soil type, soil loss, by itself, is not an appropriate proxy measure for productivity decline. For example, a loss of 1 mm from a soil in which the nutrients are concentrated close to the surface (e.g. a Luvisol – see Appendix V) will show a greater impact on productivity than the same level of soil loss from a soil in which the nutrients are more widely distributed (e.g. a Vertisol – see Appendix V).

In the following table estimates of soil loss rates under different types of land management are summarised. These rates are based on typical soil loss plot data from Zimbabwe. They demonstrate the huge impact that manipulation of the environment by humans can have on rates of soil erosion. The rate of soil loss from bare soil is 250 times that from areas covered by natural forest. Even the rate of soil loss from a well-managed cropping system is 10 times greater than that from under natural ground cover. Natural forest best represents the situation where soil loss is in approximate balance with the rate of soil formation.

Table 2.1: Typical Relative Measures of Soil Loss According to Land Use

Land use	*Soil Loss Rate (tonnes/ ha/yr)*
Bare soil	125.0
Annual crops – poor management on infertile soil	50.0
Annual cropping – standard management	10.0
Annual cropping – good management	5.0
Perennial crops – little disturbance	2.0
Natural forest	0.5

Source: This table is based on soil loss plot results from Zimbabwe, on a 9% slope.

Although land degradation is defined by reference to productivity, its effects may include diminished food security, reduced calorie intake, economic stresses and loss of biodiversity. These consequences concern rural land users greatly, and will be addressed wherever possible in the following chapters as an important part of field assessment of land degradation.

2.2 Causes of Land Degradation

Although degradation processes do occur without interference by man, these are broadly at a rate which is in balance with the rate of natural rehabilitation. So, for example, water erosion under natural forest corresponds with the subsoil formation rate. Accelerated land degradation is most commonly caused as a result of human intervention in the environment. The effects of this intervention are determined by the natural landscape. The most frequently recognised main causes of land degradation include:

(i) overgrazing of rangeland;
(ii) over-cultivation of cropland;
(iii) waterlogging and salinization of irrigated land;
(iv) deforestation; and
(v) pollution and industrial causes.

Within these broad categories a wide variety of individual causes are incorporated. These causes may include the conversion of unsuitable, low potential land to agriculture, the failure to undertake soil conserving measures in areas at risk of degradation and the removal of all crop residues resulting in 'soil mining' (i.e. extraction of nutrients at a rate greater than resupply). They are surrounded by social and economic conditions that encourage land users to overgraze, over-cultivate, deforest or pollute. These are considered in the following chapter.

It is possible to distinguish between two types of land degrading actions. The first is unsustainable land use. This refers to a system of land use that is wholly inappropriate for a particular environment. It is unsustainable in the sense that, unless corrected, this land use or indeed any other could not be continued into the future. Unsustainability has the implication of being irreversibly degrading. Many 'badlands' (extremely bare, devegetated and eroded slopes) are effectively irreversible. However, a large input of technology could start a rehabilitation process, if enough time and resources were to be devoted. Usually, this is uneconomic. Secondly, inappropriate land management techniques also cause land degradation, but this degradation may be halted (and possibly reversed) if appropriate management techniques are applied.

The effect of a land degrading process differs depending on the inherent characteristics of the land, specifically soil type, slope, vegetation and climate. Thus an activity that, in one place, is not degrading may, in another place, cause land degradation because of different soil characteristics, topography, climatic conditions or other circumstances. So, equally erosive rainstorms occurring above different soil types will result in different rates of soil loss. It follows that the identification of the causes of land degradation must recognise the interactions between different elements in the landscape which affect degradation and also the site-specificity of degradation.

2.3 Farmers' Concerns

A distinction is made between productivity, which is defined as the inherent potential of a land system to produce crop yields, and production, which is defined as the actual yield levels achieved by farmers. Land degradation may reduce the inherent productivity of a system, but production levels may be unaffected, or may increase as a result of compensating action being taken by the land user (for example, the application of fertiliser). Land management practices may not exploit the full potential productivity of the land.

Land degradation, if defined as a loss in productivity, is closely aligned with the interests of farmers, whose major concern is the yield that they can achieve from their lands. Although current harvest potential is critical to most farming decisions, farmers will often take a long term approach to land productivity. Farming activities can trigger or exacerbate land degradation, storing up future problems for land users. Consequently, early identification of risk-prone areas and management techniques is of interest to land users. These issues are explored more fully in the following chapter (3).

2.4 Sensitivity and Resilience

Sensitivity and resilience are measures of the vulnerability of a landscape to degradation. These two factors combine to explain the degree of vulnerability.

<u>Sensitivity</u> is the degree to which a land system undergoes change due to natural forces, human intervention or a combination of both. Some places are more likely to be sensitive to change – for example, steep slopes, areas of intense rainfall or highly erodible soils. These places are subject to natural hazards that make them sensitive to change. Human intervention in these systems can result in dramatic alterations. Sensitivity to change can arise as a result of human intervention – for example, in a natural state, forested hillsides may be difficult to

degrade, but once converted to farmland degradation may occur more easily.

Resilience is the property that allows a land system to absorb and utilise change, including resistance to a shock. It refers to the ability of a system to return to its pre-altered state following change. The natural resilience of an environment may be enhanced by the diversity of the land management practices adopted by land users. Degraded land is less resilient than undegraded land. It is less able to recover from further shocks, such as drought, leading to even further degradation.

Table 2.2 summarises the relationship between resilience and sensitivity of ecosystems. Where a landscape is susceptible to change (high sensitivity) the risk of degradation is affected by the resilience of that landscape – high resilience lessens the danger of serious degradation, whereas low resilience indicates that changes are not likely to be easily reversible and may even be permanent. Land systems that exhibit high resilience are likely to return to their previous stable state following disruption, whereas systems with low resilience are more likely to be permanently altered by such disruption.

Table 2.2: Sensitivity and Resilience

Resilience \ *Sensitivity*	*High*	*Low*
High	Easy to degrade Easy to restore capability	Hard to degrade Easy to restore capability
Low	Easy to degrade Difficult to restore capability	Hard to degrade Hard to restore capability

Advance recognition of the sensitivity and resilience of a land system should influence land use decisions, thereby reducing the risk of permanent degradation to the system. Similarly, the sensitivity and resilience of specific soil types also alerts the field assessor to the risk of permanent or temporary soil degradation. For example, an iron-rich but highly weathered and acid Ferralsol (see Appendix V) of the humid tropics has a low sensitivity to degradation as well as low resilience. So, once it has been degraded

Table 2.3: Examples of How Resilience and Sensitivity are Affected by Different Factors

	Intensive Rainfall	*Low SOM*	*Steep Slopes*	*Sodic Soils*	*Poor Management*	*Drought*	*Deforestation*	*Luvisol*	*Vertisol*
Vertisol	Low S Low R	Low S Low R	N/A	Mod S Low R	Low S Mod R	High S Low R	High S Low R	N/A	
Luvisol	High S High R	High S High R	High S Low R	N/A	High S High R	High S High R	High S Mod R		
Deforestation	High S High R	High S Mod R	High S Low R	High S Low R	High S Mod R	High S Mod R			
Drought	N/A	High S Low R	High S Low R	High S Low R	High S Mod R				
Poor Management	OF = S Low R	High S Mod R	High S Low R	High S Low R					
Sodic Soils	High S Low R	High S Low R	N/A						
Steep Slopes	High S Low R	High S Mod R							
Low SOM	High S High R								
Intensive Rainfall									

S = Sensitivity R = Resilience OF- Determined by combination of other factors
SOM = Soil Organic Matter

(which is difficult to do in a physical sense), then it is almost impossible to bring back to a productive state. Contrast this with a Phaeozem (see Appendix V) that has high organic matter and an excellent structure. Under good management Phaeozems give consistently high yields, but with poor management they degrade very quickly. This high sensitivity is moderated somewhat by a high resilience, because using organic methods the soil can be rehabilitated fairly quickly.

2.5 What Characteristics Contribute to Sensitivity and Resilience?

The factors that affect sensitivity and resilience of an environment are the inherent characteristics of that environment (i.e. soil properties such as nutrient reserves, soil structure, micro-aggregates and soil depth, topography, climate etc.), and the human element, in the form of land use and management practices. The salient features affecting sensitivity and resilience will vary from place to place.

So, with regard to aspects of land degradation, sensitivity refers to how easy it is to degrade the land, and resilience to how easy it is to restore the land. Some combinations of factors that may influence the sensitivity and resilience of land systems are suggested in Table 2.3. The factors listed in the matrix were selected randomly. This matrix illustrates how different combinations of factors affect the sensitivity and resilience of a system in different ways. For example, the sensitivity of a Vertisol to intensive rainfall is low (i.e. hard to degrade), whereas when intensive rainfall is combined with steep slopes sensitivity, and the risk of degradation, is high. Similarly, poor management of steep slopes is likely to result in degradation which would be difficult to reverse (i.e. low resilience), whereas a poorly managed Luvisol is highly resilient and thus more easy to restore to capability.

2.6 Scientific Interpretation of Degradation Compared to Land Users' Perceptions

Often, the views of scientist and the opinions of land users do not coincide. As discussed in Chapter 1, the land user's concern is most likely to be production. Thus, the existence of land degradation, of itself, is unlikely to be a cause of much concern, unless it has an adverse effect on productivity. What may be seen by a scientist as a potentially degrading situation may have a different significance for farmers. Some examples of the interpretations of land degrading processes by both scientists and farmers are set out in Table 2.4 below. These represent two extremes – most often there is overlap between the understanding of the land

Table 2.4: Two Extremes in the Interpretation of Outcomes of Land Degradation Evidence

Scientific Interpretation	*⇐ Process ⇒*	*Land Users' Interpretation*
High erosivity and potential soil erosion	Heavy rainfall	Damage to crops. But also benefit to soil and planting opportunity.
Loss of finer soil particles through water or wind erosion	Stones on the soil surface	Soil formation (Burungee people, Dodoma region, Tanzania)
Increased risk of soil loss through water erosion	Planting crops up and down steep slopes rather than across	Protection of crop from waterlogging and/or wind damage
Severe erosion and abuse of catchment	Deep gullies	Livestock fatalities and loss of roads/bridges
Severe short term erosion, indicating need for better cover	Rills	Useful local drainage channels to prevent waterlogging and into which to place weeds
Soil and water conservation measure to trap soil and conserve water	Barriers across the slope intercepting soil	Convenient way to subdivide garden for planting and management purposes
Danger of erosion and need to instigate organic conservation measures to decrease erodibility	Erodible soils	Opportunity to harvest sediment at bottom of slope and create new field

user and the scientist. It is important to understand how land users perceive processes of land degradation if discussions about land degradation and preventative measures are to have any relevance for them.

The accurate measurement of soil loss through erosion may be of interest to scientists. However, land users are generally more concerned about the effects of erosion than the absolute amount of soil loss. These *Guidelines* focus on quick methods of measuring soil loss and of assessing negative effects on the productivity of the land. They do not seek to describe procedures that will give results which would meet the rigours of scientific measurement. Instead, their aim is to provide extension workers and land users with accessible techniques that will provide a sufficient basis for planning future actions to protect and increase the productivity of the land.

2.7 Scales of Field Assessment

Land degradation occurs at widely varying rates, and to varying degrees, over the landscape, hillside and between fields. As noted in the previous chapter, the focus of these *Guidelines* is on the local scale. Levels of degradation are considered by reference to farms and individual fields. In the case of rangelands, degradation refers to dispersed features, such as tree mounds and gullies. The local-scale focus, together with the farmer perspective, dictate the type of measurements that are appropriate The methods described in Chapter 4 of these *Guidelines*, in relation to the measurement of soil loss, are particularly suited to field and farm scale. They accommodate the fact that soil loss does not occur uniformly across plots or hillsides, and instead allow for the variability within the natural landscape that affects the amounts of soil loss and run-off from apparently homogenous fields. They are also measurements of soil loss and accumulations that can be readily observed by the land user.

The perception of the scale and seriousness of land degradation will be influenced by the timing of any investigation. Many forms of soil loss are most easily seen during or shortly after periods of heavy rains. Some types of erosion may be less visible after crops become established in fields. Nutrient deficiencies and other factors that affect crop production will be best observed when crops are in-field and relative growth rates can be assessed. Actual production is best assessed at harvest times when output can either be weighed, or the standard number of units (sacks/bundles) counted. Repeated measurements give a more complete picture of the effects of the processes leading to land degradation.

The causes and effects of land degradation can occur both on- and off-site. On-site effects of land degradation lead to a lowering of the land's productive capacity, resulting in reduced yields or a need for higher inputs. These costs are borne directly by the land user thus affecting interest in reducing or reversing land degradation. The land user's ability to remedy the land degradation depends on whether the cause is on- or off-site. Off-site effects of land degradation are problems exported and borne by others. The most common off-site effects include sedimentation in reservoirs and waterways, decline in water quality and contamination of drinking water, gully erosion and deposition of eroded materials on farmland.

Because the causes and effects of land degradation are unaffected by the boundaries of land ownership or use rights, degradation may occur on a farmer's land as a result of actions taken by other land users upslope. Similarly, actions taken on a farmer's field may affect other land users downslope. Therefore the interest in preventing land degradation may not coincide with the cause. This has serious implications when it comes to assessing the costs and benefits of different courses of action. For example, if upstream soil erosion causes siltation of a reservoir, from the reservoir operator's point of view the net benefits that accrue from incurring expenses to reduce or eliminate the erosion may well outweigh the costs of doing nothing. However, the land user whose farm is the source of the deposited soil is unlikely to attach the same level of benefit to the reduction of soil loss.

2.8 Levels of Analysis of Degradation

The examination of field degradation at different scales feeds into different levels of analysis. Each level has its own particular set of uses. The first and most immediate use of information relating to existing or potential degradation is to identify the risks at field and farm level. Mapping of fields and detailed site inspection are involved here. The next level is to rank the degrees of actual degradation, or future risk of degradation, by reference to their seriousness. This allows the land user to prioritise possible responses to degradation risk and to target parts of the farm where risk is greatest. The field assessor may use this level of analysis to make semi-quantitative comparisons between sites and situations. A third level of analysis is to formalise the prioritisation by farmers by attaching monetary values to the costs (time, labour, money) and to the benefits of any course of action (including 'doing nothing').

<u>(i) Mapping of fields:</u>

The first step in assessing land degradation is to take stock of the visual evidence of degradation in the area under review. The physical aspects of the landscape must be observed and evaluated. Preparing a map of the area under review (farmer's field or farm) will help to identify areas at particular risk of degradation due to the naturally occurring features in the landscape. Discussions with farmers will furnish important information about yield and the vigour of plant growth in different areas of the field.

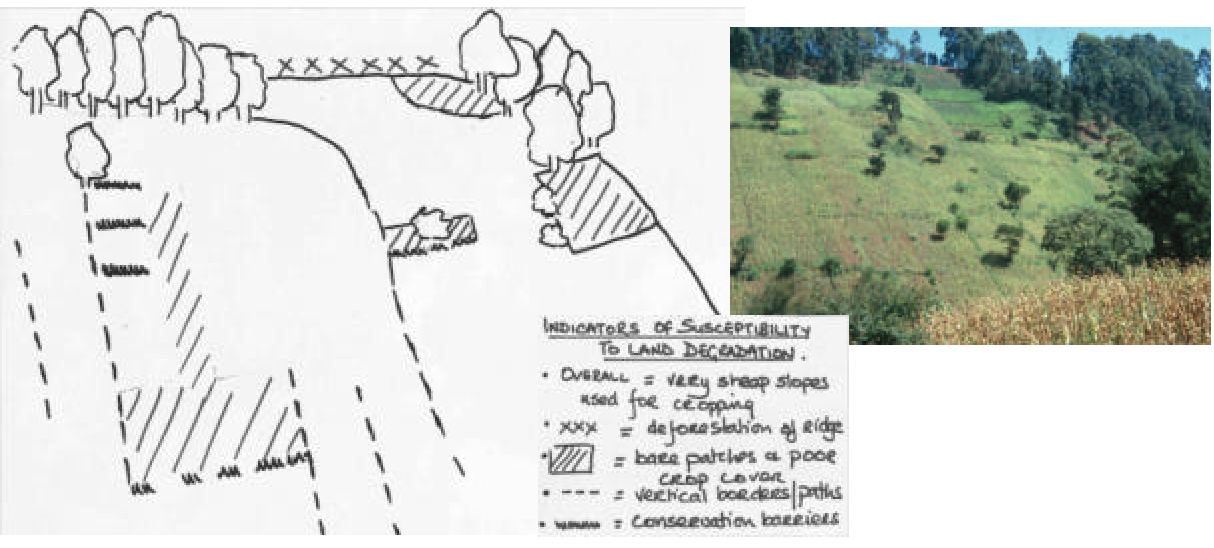
The site-specific characteristics identified at this stage help to identify where the highest risks of land degradation lie within a field, farm or over a larger area. A systematic approach to mapping of the area under review will identify not only existing degradation but will pinpoint areas at risk from future degradation. Since land degradation occurs as a result of the combined effects of soil characteristics, slope angle, climate and land management, changes introduced by the land manager will affect the risks of land degradation.

The mapping of the area under investigation aims to identify the causes of degradation and to explain why some parts of the area under review may be more susceptible to degradation than others. Proportionally more effort may be required by the land user to protect susceptible areas from future degradation.

<u>(ii) Ranking risks according to seriousness:</u>

Having mapped (in-field or on-farm) the actual degradation occurring and the potential for

<u>Box 2.2: Landscape and Map Sketch of a Small-Farm Agricultural Landscape in Kenya Showing Susceptibility to Land Degradation</u>



further degradation in the future, the identified risks can be ranked based on their seriousness. Chapter 6 gives some guidance on how this ranking can be carried out, not only to assess the risks but also to provide a tool to assist future decision-making. This ranking leads into action plans for combating land degradation, allowing land users to prioritise the focus of their conservation/land degradation prevention activities.

<u>(iii) Cost-benefit analysis:</u>

The identification and ranking of the risks of land degradation forms the data for further analysis. It enables farmers to estimate the costs and benefits of measures and techniques that will reduce or eliminate land degradation, and to compare these with the costs and benefits of doing nothing. This kind of assessment, known as cost-benefit analysis, underlies the process of making decisions about investment in land and farming activities in both smallholder and commercial agriculture. Whether or not to invest in a capital or labour intensive activity will depend on the perceived benefit of it to the person making the investment. This latter point is important – while economics enables us to carry out simulated cost-benefit analysis for decision-making purposes, ultimately the analysis is subjective relying on the values attached to specific costs and benefits by individual land users. Consequently, two farmers living side by side, with similar farms in terms of area, topography and fertility may make widely different decisions about land management issues, be it the crop to be planted, the fertility treatment to be undertaken or physical conservation measures to be dug. This subjectivity reflects the circumstances of the individual land user.

Cost-benefit analysis must not be seen as a prescriptive tool. It cannot be applied mechanically to arrive at a single 'right answer'. Capturing the costs and benefits that are important to the individual is the best way of getting close to the 'right answer' for that farmer.

These *Guidelines* will not deal with cost-benefit analysis in detail – it is really an extension of field assessment and a way of using data to gain a view of the likelihood of farmer's decisions on whether to invest. However, it is important that the field assessor gains the information about the important variables for undertaking cost-benefit analysis, so that the analysis can be accomplished later using any one of the many manuals that describe how to do it. The variables of greatest importance for a farmer-perspective cost-benefit analysis are:

- **Costs**: these must reflect the real costs to the farmer of undertaking any protection measure against land degradation. The largest cost is usually labour, and the field assessor needs to get a good view of what other activities the farmer cannot undertake in order to accomplish the conservation (this is the opportunity cost of labour). Similarly, there are costs in land and capital, which must be realistically assessed. The input of farmers is vital in making these assessments.
- **Benefits**: these must also reflect the real benefits to farmers. There are direct benefits such as increased yields; but the indirect benefits can be larger. For example, reduction in weeding because of a good cover crop, or reduced ploughing costs because of better soil structure, are legitimate ways in which reduction in land degradation brings benefits to land users.

Other important variables include time horizon (what planning horizon does a farmer use?), the discount rate and the valuation approach. Guidance on these, and other issues relating to cost-benefit analysis, can be found in most economics textbooks. Several useful references are suggested in Appendix IV.

Cost-benefit analysis of land degradation is considered further in Chapter 8, section 8.4, in terms of appraising a conservation technology. The principles are identical, whether the assessor wants to know whether land degradation is costly, or conservation is worthwhile.