Soil Erosion is a common term that is often confused with soil degradation as a whole, but in fact refers only to absolute soil losses in terms of topsoil and nutrients. This is indeed the most visible effect of soil degradation, but does not cover all of its aspects. Soil erosion is a natural process in mountainous areas, but is often made much worse by poor management practices.

Land degradation has a wider scope than both soil erosion and soil degradation in that it covers all negative changes in the capacity of the ecosystem to provide goods and services (including biological and water related goods and services – and in LADA's vision - also land-related social and economic goods and services).

Desertification is another common term used for (a) land degradation in dryland areas and/or (b) the irreversible change of the land to such a state it can no longer be recovered for its original use.

Prevention implies the use of conservation measures that maintain natural resources and their environmental and productive

Mitigation is intervention intended to reduce ongoing degradation. This comes in at a stage when degradation has already begun. The main aim here is to halt further degradation and to start improving resources and their functions. Mitigation impacts tend to be noticeable in the short to medium term: this then provides a strong incentive for further efforts. The word 'mitigation' is also sometimes used to describe the reductions of impacts of degradation.

Rehabilitation is required when the land is already degraded to such an extent that the original use is no longer possible and the land has become practically unproductive. Here longer-term and often more costly investments are needed to show any impact.

Soil Degradation

Soil degradation is the decline in **soil** quality caused by its improper use, usually for agricultural, pastural, industrial or urban purposes. **Soil degradation** is a serious global environmental problem and may be exacerbated by climate change. It encompasses physical, chemical and biological deterioration.

Soil degradation is defined as a **change in the soil health status resulting in a diminished capacity of the ecosystem to provide goods and services for its beneficiaries**. Degraded soils have a health status such, that they do not provide the normal **goods** and **services** of the particular soil in its **ecosystem**.

These definitions, which follow largely the LADA definition of land degradation, are important to capture the complexity of the degradation processes and their subjective evaluation by different stakeholders in soil and land.

Soil degradation

Soil degradation is the decline in soil quality caused by its improper use, usually for agricultural, pastural, industrial or urban purposes.

Soil degradation is a serious global environmental problem and may be exacerbated by climate change. It encompasses physical, chemical and biological deterioration. Examples of soil degradation cited by Charman and Murphy (2005) are loss of organic matter, decline in soil fertility, decline in structural condition, erosion, adverse changes in salinity, acidity or alkalinity, and the effects of toxic chemicals, pollutants or excessive flooding.

Soils host the majority of the world's biodiversity and healthy soils are essential to securing food and fibre production and providing an adequate water supply over the long term. Ecosystem services provided by soils are integral to the carbon and water cycles and include cultural functions. There are strong links between climate change and soil condition. Increases in soil carbon can help to mitigate Australia's greenhouse gas emissions and enhance adaptation to climate change.

Soils are one of NSW's fundamental natural resources. Therefore, maintaining and improving the condition of the State's land and soil resources by avoiding soil degradation is crucial to our well-being. The NSW State Plan includes two State-wide targets for land and soil management. They are:

- improve soil condition
- Increase the area of land managed within its capability.

To measure progress towards achieving these targets, a program for land and soil condition*monitoring, evaluation and reporting* (MER) has been developed. The Office of Environment and Heritage (OEH) is leading the implementation of this program.

The statewide MER program measures and reports on the status and change in a range of land and soil 'indicators', including those of regional significance. Supporting information includes land use and land management data and the provision of spatial information about land and soil capability.

Soil environmental issues:

Many environmental issues directly affect soils and many environmental issues are influenced by land and soil management. These issues include:

- Soil carbon
- Soil biodiverstiy
- Acid sulfate soils
- Salinity
- Wind erosion
- Gully erosion
- Sheet erosion
- Soil acidification
- Structure decline
- Land capability

Different Types of Land degradation

In addition to the usual types of land degradation that have been known for centuries (water, wind and mechanical erosion, physical, chemical and biological degradation), four other types have emerged in the last 50 years:

- pollution, often chemical, due to agricultural, industrial, mining or commercial activities;
- loss of arable land due to urban construction;
- artificial radioactivity, sometimes accidental;
- land-use constraints associated with armed conflicts.

Overall, 36 types of land degradation can be assessed. All are induced or aggravated by human activities, e.g. sheet erosion, silting, aridification, salinization, urbanization, etc.

Causes of Land degradation

Soil compaction, low organic matter, loss of **soil** structure, poor internal drainage, salinisation and **soil** acidity problems are other serious **soil degradation** conditions that can accelerate the **soil erosion** process. This Factsheet looks at the **causes** and effects of water, wind and tillage **erosion** on agricultural land.

Land degradation is a process in which the value of the biophysical environment is affected by a combination of human-induced processes acting upon the land.[1] Also environmental degradation is the gradual destruction or reduction of the quality and quantity of human activities, animal's activities or natural means example water causes soil erosion, wind, etc. It is viewed as any change or disturbance to the land perceived to be deleterious or undesirable.[2] Natural hazards are excluded as a cause; however human activities can indirectly affect phenomena such as floods and bush fires.

This is considered to be an important topic of the 21st century due to the implications land degradation has upon agronomic productivity, the environment, and its effects on food security.[3] It is estimated that up to 40% of the world's agricultural land is seriously degraded.[4]

Land degradation is a global problem, largely related to agricultural use. The major causes include: Land clearance, such as clearcutting and deforestation

- Agricultural depletion of soil nutrients through poor farming practices
- Livestock including overgrazing and overdrafting
- Inappropriate irrigation[7] and overdrafting

- Urban sprawl and commercial development
- Soil contamination
- Vehicle off-roading
- Quarrying of stone, sand, ore and minerals
- Increase in field size due to economies of scale, reducing shelter for wildlife, as hedgerows and copses disappear
- Exposure of naked soil after harvesting by heavy equipment
- Monoculture, destabilizing the local ecosystem
- Dumping of non-biodegradable trash, such as plastics

Causes of land degradation

1. **Natural degradation hazards**
2. **Direct causes of degradation**
3. **Underlying causes of degradation**
4. **Land, population, poverty and degradation: the causal nexus**

The causes of land degradation can be divided into natural hazards, direct causes, and underlying causes. Natural hazards are the conditions of the physical environment which lead to the existence of a high degradation hazard, for example steep slopes as a hazard for water erosion. Direct causes are unsuitable land use and inappropriate land management practices, for example the cultivation of steep slopes without measures for soil conservation. Underlying causes are the reasons why these inappropriate types of land use and management are practised; for example, the slopes may be cultivated because the landless poor need food, and conservation measures not adopted because these farmers lack security of tenure.

There is a distinction, although with overlap, between unsuitable land use and inappropriate land management practices.

Unsuitable land use is the use of land for purposes for which it is environmentally unsuited for sustainable use. An example is forest clearance and arable use of steeply sloping upper watershed areas which would have more value to the community as water sources, managed under a protective forest cover.

Inappropriate land management practices refer to the use of land in ways which could be sustainable if properly managed, but where the necessary practices are not adopted. An example is the failure to

adopt soil conservation measures where these are needed. It can also refer to land use which is ecologically sustainable under low intensity of use but in which the management becomes inappropriate at higher intensifies. Examples are shifting cultivation and the grazing of semi-arid rangelands.

The GLASOD assessment gives one or two causes for each map unit and type of degradation. In this assessment, only four causes were recognized, defined as:

- de fore station and removal of natural vegetation;
- overgrazing;
- agricultural activities;
- over-exploitation of vegetation for domestic use.

This survey did not recognize a separate class of problems arising in the planning and management of irrigation, but it is clear from the results that such problems are included under agricultural activities.

The results from the GLASOD assessment of causes is summarized in Table 20. Other information on causes is from publications and persona! information.

TABLE 20 - **Causes of degradation as given in the GLASOD assessment**

Type of degradation	**Percentage area of degradation type caused by**			
	Deforestation	**Overgrazing**	**Agricultural activities**	**Overcutting of vegetation**
Water erosion	61	67	2	44
Wind erosion	21	46	1	98
Soil fertility decline	25	0	75	0
Salinization	34	30	14	87
Waterlogging	0	0	85	33
Lowering of water table	12	22	65	34
All types of degradation	37	46	15	63

NB: Up to two causes are given for each type of degradation, therefore percentages sum to more than 100.

1. Natural degradation hazards

The major natural hazards in the region, environmental conditions which act as predisposing factors for land degradation, are:

For water erosion:

- monsoonal rains of high intensity;
- steep slopes of the mountain and hill lands;
- soils with low resistance to water erosion (e.g. silty soils, vertisols).

For wind erosion:

- semi-arid to aria climates;
- high rainfall variability, with liability to drought spells;
- soils with low resistance to wind erosion (e.g. sandy soils).
- an open cover of natural vegetation.

For soil fertility decline:

- strong leaching in humid climates;
- soils which are strongly acid, and/or with low natural fertility.

For waterlogging:

- alluvial plains or interior basins which restrict outward drainage of groundwater.

For salinization:

- semi-arid to aria climates with low leaching intensity;
- plains and interior basins which restrict outward drainage of groundwater;
- soils which are naturally slightly saline.

For lowering of the water table:

- semi-arid to aria climates with low rates of groundwater recharge.

In some cases, these natural hazards are of sufficient intensity to give rise to unproductive land without human interference. Examples are the naturally saline soils which occur in some interior basins of dry regions, or areas of natural gullying ('badlands'). Such conditions have been referred to as problem soils. Percentages of land covered by problem soils are given in Dent (1990).

With respect to land degradation, the key feature is that land shortage in the region has led to the widespread agricultural use of areas with natural hazards. These are the passive, or predisposing, conditions for land degradation. Problem soils require special care in management, and failure to give such care leads to land degradation.

2. Direct causes of degradation

Deforestation of unsuitable land Deforestation is both a type of degradation as such, and also a cause of other types, principally water erosion. Deforestation in itself is not necessarily degrading without it, most productive agricultural lands (in the temperate zone as well as the tropics) would not be available. Deforestation becomes a cause of degradation first, when the land that is cleared is steeply sloping, or has shallow or easily erodible soils; and secondly, where the clearance is not followed by good management.

The extent of deforestation considered as a type of degradation has been summarized in Chapter 5, Section Deforestation and forest degradation. It is the leading cause of water erosion in steeply sloping humid environments. It is also a contributory cause of wind erosion, soil fertility decline and salinization.

Overcutting of vegetation Rural people cut natural forests, woodlands and shrublands to obtain timber, fuelwood and other forest products. Such cutting becomes unsustainable where it exceeds the rate of natural regrowth. This has happened widely in semi-arid environments, where fuelwood shortages are often severe. Impoverishment of the natural woody cover of trees and shrubs is a major factor in causing both water erosion and wind erosion. In the GLASOD assessment it is cited as a cause for 98% of the area affected by wind erosion. This assessment also cites it as a contributory cause to salinization.

Shifting cultivation without adequate fallow periods In the past, shifting cultivation was a sustainable form of land use, at a time when low population densities allowed forest fallow periods of

sufficient length to restore soil properties. Population increase and enforced shortening of fallow periods has led to it becoming non-sustainable. Shifting cultivation is found in the hill areas of northeast India, where it is a cause of water erosion and soil fertility decline.

Overgrazing. Overgrazing is the grazing of natural pastures at stocking intensifies above the livestock carrying capacity. It leads directly to decreases in the quantity and quality of the vegetation cover. This is a leading cause not only of wind erosion, but also of water erosion in dry lands. Both degradation of the vegetation cover and erosion lead to a decline in soil organic master and physical properties, and hence in resistance to erosion.

Intense grazing at the end of the annual dry season, and during periods of drought, does not necessarily lead to degradation; the vegetation may recover during the succeeding rains. Degradation occurs when the recovery of vegetation and soil properties during periods of normal rainfall does not reach its previous statue.

Non-adoption of soil-conservation management practices Under arable use, management practices are needed to check water erosion on all sloping lands. In dry lands, measures to check wind erosion are necessary also on lever land. Soil conserving management practices may be grouped into:

- Biological methods: maintenance of a "round surface cover, of living plants or plant litter; vegetative barriers, including both contour hedgerows and grass strips; and windbreaks and shelterbelts.
- Earth structures: terraces, and the various forms of bank-and ditch structures (bunds, storm drains, etc.).
- Maintaining soil resistance to erosion: primarily, maintenance of soil organic master and thereby aggregation and structure.

Great efforts have been made by soil conservation services in the countries of the region to promote the adoption of such management practices. In some areas, these efforts have achieved a considerable measure of success. In others, staff and resources have been greatly deficient, or adoption of recommended methods poor. The recent change of emphasis in soil conservation with more use of biological methods, including agroforestry, and greater stress on farmers' participation and economic incentives, has not yet been fully taken up by extension services.

Often, it is not the environment nor the type of land use which necessarily leads to degradation, but the standard of management. A clear example is seen in tee production in the hill lands of Sri Lanka. Well-managed farms maintain a complete vegetation cover, which checks erosion even on steep slopes; on poorly-managed farms, rainfall strikes bare soil between plants, leading in places to very severe degradation.

Extension of cultivation onto lands of longer potentiel and/or high natural hazards These are also called 'fragile' or marginal lands. Historically the more fertile, or high-potential, agricultural lands were the first to be occupied. Population increase has led to the widespread use of lands of longer potential, those which are less fertile or have greater degradation hazards. Such marginal lands include:

- steeply sloping land;
- areas of shallow or sandy soils, or with laterite crusts;
- cultivation of semi-arid lands, and grazing of the crier semi-arid areas, marginal to deserts.

Such land is of great extent in the region, and makes a large contribution to its agricultural production. Except in areas of highest environmental hazards, e.g. upper watersheds, it is neither desirable nor practicable that they should be taken out of production. What must be recognized is that such lands require higher standards of management if their resources are to be conserved. Unfortunately, they are often utilized by poorer farmers.

Improper crop rotations As a result of population growth, land shortage and economic pressures, farmers in some areas have adopted cereal-based, intensive crop rotations, based particularly on rice and wheat, in place of the more balanced cereal-legume rotations that were formerly found. This is a contributory cause of soil fertility decline.

Unbalanced fertilizer use Where soil fertility has declined, as a result of prolonged cultivation or erosion, farmers attempt to maintain crop yields. The primary method available for doing so is application of fertilizer. In the short term, a yield response is most readily and cheaply obtained from nitrogenous fertilizer. There has been a steady increase in the ratios of nitrogen to phosphorus, and nitrogen to all other nutrients, in the region. Where phosphate deficiencies have been recognized and counteracted by phosphatic fertilizer, deficiencies of other nutrients, including sulphur and zinc, have been reported.

The short-term measure of combatting fertility decline by application only of macronutrients, and particularly nitrogenous fertilizer, is leading to a greater problem of nutrient imbalance in the medium term. Among the consequences is likely to be longer yield responses to fertilizers.

Problems arising from planning and management of canal irrigation The development of salinization and waterlogging on the large-scale canal irrigation schemes of the Indo-Gangetic plains has been frequently described. Application of water in excess of natural rainfall led to a progressive rise in the water table from the 1930s onward. Where the water table has reached close to the surface, waterlogging occurs leading, through evaporation of water containing salts, to salinization. Sodification follows where sodium replaces other bases in the soil exchange complex. The problem could have been avoided, or reduced, if deep drains had been included in the initial implementation of irrigation schemes. More detailed accounts of the complex processes involved will be found in development planning studies of Pakistan and Indian irrigated areas.

Overpumping of groundwater In areas of non-saline ('sweet') groundwater, the technology of tubewells has led to abstraction of water in excess of natural recharge by rainfall and river seepage. This has progressively lowered the water table, as in Iran, India and Pakistan.

3. Underlying causes of degradation

There are more basic reasons underlying the reasons for land degradation outlined above. They apply to all direct causes, other than the problems of large-scale irrigation schemes which arose from lack of foresight in planning and management.

Land shortage It has always been recognized that land is a finite resource, but only recently has the full impact of this fact occurred. In earlier times, food shortage or poverty could be combatted by taking new, unused, land into cultivation. Over most of South Asia, this solution is no longer available. The percentage change in agricultural land over the ten years 1980-1990 is under 2.5% for India, Pakistan, Sri Lanka and Afghanistan, whilst for Bangladesh there has been a small absolute decrease. The increase recorded for Nepal has certainly been obtained by deforestation and taking into agricultural use sloping land which is difficult to farm on a sustainable basis.

When combined with increases in rural population, land shortage has led to decreases in the already small areas of agricultural land per person in six of the eight countries, including all in the humid zone.

The relative decrease in land per person over 1980-90 was 14% for India and 22% for Pakistan. In Iran, with a smaller rural population increase, the land/people ratio has remained virtually constant.

There is almost no unused but usable land in South Asia. All of the best land is already taken up, and that which is not, cannot be used agriculturally on a sustainable basis.

Land tenure: tenancy and open access resources Farmers will be reluctant to invest in measures to conserve land resources if their future rights to use these resources are not secure. Two kinds of property rights lead to this situation, tenancy and open access resources.

Despite efforts by legislation and land reform programmes over many years, tenant occupation of farmland is still very widespread. The landowner is now frequently from the cities, and the land is farmed by tenants paying some form of rental. Relations between landlord and tenant are often good, and the tenant in fact remains on the same farm for many years. However, such tenants lack the incentive to maintain the land in good condition, being interested mainly in the immediate harvest.

Open access land resources are those which anyone, in practice the poor and otherwise landless, can use, without rights of continuing usufruct or tenure. This applies mainly to forest lands, nominally under government ownership but which are settled on a squatter basis.

There is a distinction between common property and open access resources. In common property resources, use is restricted to members of a community, village or clan, and is subject to constraints, socially applied. For example, pastoralists often have customs for when certain areas must be rested from grazing, villages restrict the cutting of communal woodland. On open access land there are no such constraints. With no legal basis to their use, incentive to farm the land other than for immediate needs is completely lacking. This is a serious cause of deforestation followed by water erosion.

Economic pressures and attitudes Small land holdings lead to severe economic pressures on farmers, to obtain sufficient food and income to meet immediate needs. Because of such pressure in the short term, labour, land and capital resources cannot be spared to care for the land, for example green manuring or soil conservation structures. This is also the underlying reason for two other direct causes noted above, improper crop rotations and unbalanced fertilizer use.

A contributory factor, not always appreciated by outside observers, is a change in economic attitudes. In former times, most farmers accepted the situation into which they were bore, even if it was one of

relative poverty. Modem communications and influence have led to greater aspirations and consequent requirements for income, thus increasing economic pressures.

Poverty Countries of the region have made great progress in economic development, achieving increases in gross domestic product per capita. It is questionable whether there have been corresponding improvements in the real welfare of the rural poor. The majority of farmers remain close to, or below, the margin of poverty, defined as access to basic necessities of life.

Poverty leads to land degradation. It could almost certainly be shown that richer farmers maintain their soils in better state than poorer. Research based on sample studies to confirm this is desirable.

Population increase Together with land shortage, the second basic cause of degradation is the continuing increase in rural, agricultural, population. Growth rates for total population 19801990 for six countries range from 2.1-3.6% per year (for Afghanistan the figure is affected by migration and war). Only in Sri Lanka have attempts to reduce the rate of population increase made substantial progress, with a growth rate of 1.4%.

Urban populations are increasing faster than rural. The trend towards urbanization, however, is not sufficient to reverse the key that absolute levers of rural population have increased and are increasing. In Bangladesh, Bhutan, India, Nepal and Pakistan, rural populations were 17-32% higher in 1990 than in 1980. In absolute terms, the scale is greatest in India, where already densely populated rural areas contained 79 million more people in 1990 than 10 years earlier.

4. Land, population, poverty and degradation: the causal nexus

The direct and indirect causes of degradation are linked by a chain of cause and effect, or causal nexus (Figure 9).

The two external, or driving, forces are limited land resources and increase in rural population. Expressed another way, there are no longer substantial areas of usable, unused land in the region; but the number of people to be supported from this finite land resource is increasing every year.

These two primary forces combine to produce land shortage. This refers to increasing pressure of population on land, resulting in small farms, low production per person and increasing landlessness. A consequence of land shortage is the next element, poverty.

Land shortage and poverty, taken together, lead to non-sustainable land management practices, meaning the direct causes of degradation. For reasons outlined above, poor farmers are led to clear forest, cultivate steep slopes without conservation, overgraze rangelands, make unbalanced fertilizer applications, and the other causes noted above.

FIGURE 9 - Causal nexus between land, population, poverty and degradation

The non-sustainable management practices lead to land degradation. This leads to reduced land productivity: a lower response to the same inputs or, where farmers possess the resources, a need for higher inputs to maintain crop yields and farm incomes. This has the effect of increasing land shortage, thus completing the cycle.

Case studies illustrating the interconnections of this cycle are given in Asian Development Bank (1991).

There are two ways to check this cycle, improved technology and reduction in population increase. Improved technology could be added as a third external force in Figure 1, divided into three elements:

- land improvements (e.g. irrigation), which can reduce land shortage;
- increases in productive technology, which can reduce poverty and pressure upon land;
- better land resource conservation, which can reduce land degradation and, to a limited degree, reverse degradation.

Vast efforts have been made, by individual farmers, national governments and through international development assistance, to counteract the cycle of poverty and land degradation by research and development of improved technology. Much success has been achieved, as in the spread of high-yielding crop varieties and use of fertilizers which was (optimistically) called the 'green revolution'.

All of this effort will be nullified, and in places reversed, if it is not accompanied by a reduction in rate of growth of population. The existence of limited land resources cannot be substantially changed. The other external force, increase in population, constantly drives the cycle that leads to poverty and land degradation.

Governments of the region, as well as international agencies, recognize the priority of limiting increase in population, as evidenced by reports. There is also the beginning of an awareness that population