

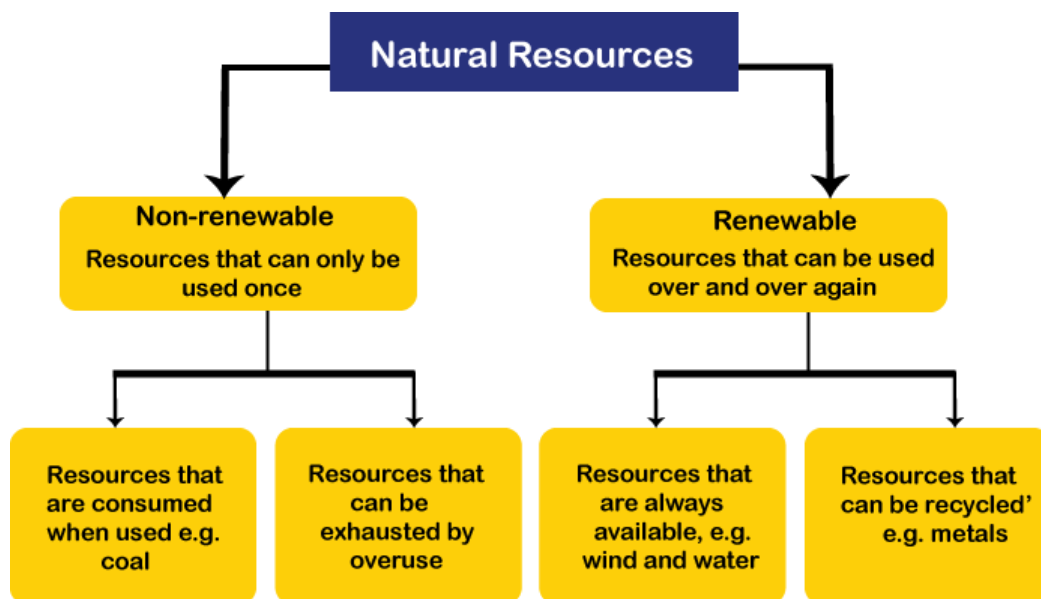
Module 1

Natural resources:

Natural resources are the parts of the environment that are highly important to humans, whether they in one form or the other. Natural resources are available in nature itself, and humans have no say in making them. Some examples of natural resources are Air, water, coal, animals, plants, natural gas, sunlight, etc. A lot of products highly important can be received through natural resources. Some examples are mentioned below:

- Air is used for the generation of wind energy.
- Animals are used for the production of food, clothes (wool, silk) etc.
- Coal is used for the production of electricity.
- Plants are used for the production of food, paper, wood etc.
- Water is used for drinking, cleaning, hydroelectricity etc.
- Sunlight is used for photosynthesis, solar power etc.

Types of Natural Resources:



Natural resources that can be generated after usage are known as renewable resources. Sunlight, water, and wood are a few examples of renewable natural resources.

Advantages	Disadvantages
Sustainable	Difficult to produce large quantities
Requires little maintenance	The reliability of supply is often dependent on weather
Produces little waste	

A nonrenewable resource is a naturally occurring substance that cannot be replenished at the rate that it is depleted.

One example of this is natural gas. Coal is another example of a non-renewable natural resource. There are numerous other natural resources, similar to coal, that are finite and cannot be reprocessed. Since the majority of these non-renewable natural resources cannot be recycled, it is crucial to conserve them. There are some natural resources that are in great demand but are less common.

Advantages	Disadvantages
Supplies are abundant so the cost is cheap	Non sustainable . We will run out
Can produce large amounts of energy	The use of them can produce pollutants

Conservation of Natural Resources

The conservation of natural resources refers to the sustainable management and responsible use of Earth's limited resources to ensure their availability for future generations. These resources include air, water, land, minerals, plants, and animals. Conservation aims to prevent depletion, degradation, or loss of these resources by employing various strategies such as reducing consumption, recycling, protecting habitats, implementing sustainable practices in agriculture and industry, and promoting environmental awareness and education.

The modern lifestyle and the advance in technology have had a very bad impact on natural resources. Natural resources like coal and petroleum are depleting at a very fast rate, and once they are depleted, we will have to depend on other sources of energy. Therefore, it is very necessary for us humans to act in a way that ensures the conservation of natural resources. There are thousands of ways of conserving natural resources. The main idea of conservation is to use natural resources with optimization, and do not waste any natural resources. All you have to do is to act according to the situation so that the use of natural resources is minimal.

For instance, using bicycles or walking sometimes saves a lot of fuel. Using public transport (city buses and metro trains) also helps in saving a lot of oil. Saving water while bathing, cleaning, etc. help in water conservation.

Need for Conservation of Natural Resources

We know that nature provides us with all our basic needs but we tend to over exploit.

If we go on exploiting nature, there will be no more resources available in future.

Hence there is an urgent need to conserve nature for the following reasons. Some of the needs are :

- To maintain ecological balance for supporting life.
- To preserve different kinds of species (biodiversity).
- To make the resources available for present and future generations.
- To ensure survival of human race.

Some important natural resources are:

- ❖ Land Resources
- ❖ Water Resources
- ❖ Air Resources
- ❖ Forest Resources
- ❖ Wildlife Resources
- ❖ Mineral Resources
- ❖ Energy Resources
- ❖ Microbial Resources

Land Resources:

The term “land resources” encompasses the physical, biotic, environmental, infrastructural and socio-economic components of a natural land unit, including surface and near-surface freshwater resources important for management.

Importance of land as a resource:

The land is considered an important resource as it **provides habitation to many flora and fauna**. Human beings use it for various purposes such as agriculture, forestry, mining, building houses and roads, and setting up industries.

Both physical and human factors determine land-use patterns.

The physical factors to determine land use patterns are:

- Soil
- Climate
- Minerals
- Topography and availability of water.

Human factors to determine land use patterns are:

- Population
- Technology

Land:

“A delineable area of the earth’s terrestrial surface, encompassing all attributes of the biosphere immediately above or below this surface including those of the near-surface climate, the soil and terrain forms, the surface hydrology (including shallow lakes, rivers, marshes and swamps), the near-surface sedimentary layers and associated groundwater reserve, the plant and animal populations, the human settlement pattern and physical results of past and present human activities”.

Uses of Land:

1. Land is used for agriculture.
2. Land contains huge amount of minerals
3. It also contains water in the form of underground water
4. Most of the animals have their habitat on land
5. Land provides all the resources required to fulfil the basic needs of human civilization such as food, cloth and shelter.

Types of Land:

1. Agricultural Land
2. Residential land
3. Commercial land
4. Industrial Land
5. Agricultural land conversion to non-agricultural use
6. Forest
7. Desert
8. Special Economic zones
9. Eco-sensitive and reserved lands

Agricultural land is typically land devoted to agriculture, the systematic and controlled use of other forms of life—particularly the rearing of livestock and production of crops—to produce food for humans. It is generally synonymous with both farmland or cropland, as well as pasture or rangeland.

A residential area is a land used in which housing predominates, as opposed to industrial and commercial areas. It includes all places where people live. Generally largest land use in most cities often taking up to 40% or more of the developed land. The two factors which influence residential density are **cost of land** and **age of the neighborhood**.

Commercial land is a distinct category of investment properties that are meant to be income-producing. Commercial land is appraised differently than residential land and also treated differently by municipalities and infrastructure providers. The value of residential real estate tends to rise every year but commercial land can fluctuate wildly based on where it is located and what other properties are located (or going to locate) nearby.

Industrial property refers to land that is used for industrial purposes. It includes small, large and enormous.

- **Small industrial sites:** These sites include single or double-storey buildings zoned for industrial use. These often have flexible interior space, usually a mix of warehouse and office space. These spaces are commonly used by businesses like mechanics, start-ups and laboratories.
- **Large industrial sites:** These sites include medium to large warehouses and factories that manufacture or store goods. They also include distribution companies such as third-party logistics.
- **Enormous spaces:** Enormous industrial spaces are preferred by logistics and

distribution companies that hold and distribute finished goods to stores and/or directly to customers.

Agricultural land conversion to non-agricultural use in some cases agricultural land may be converted to non-agricultural use, such as commercial or residential purposes. This process involves obtaining necessary **approvals** and **adhering** to the land use regulations set by local authorities.

Forests: A forest is a complex ecological system in which trees are the dominant life-form. A forest is nature's most efficient ecosystem, with a high rate of photosynthesis affecting both plant and animal systems in a series of complex organic relationships.

Deserts: A desert is a barren area of landscape where little precipitation occurs and, consequently, living conditions are hostile for plant and animal life. Deserts are formed by weathering processes as large variations in temperature between day and night put strains on the rocks, which consequently break in pieces.

Special Economic zones (SEZ's) are designated areas within the country aimed at promoting export oriented industries and boosting economic growth. They offer various incentives, such as tax benefits and simplified customs procedures to attract investments and facilitate trade.

Eco-sensitive and reserved lands to preserve the environment and protect natural habitats and certain areas are marked as eco sensitive and reserved lands. These regions may include wildlife sanctuaries, national parks and forests reserves where development is restricted to ensure ecological balance and conserve biodiversity.

Grassland:

Area in which the vegetation is dominated by a nearly continuous cover of grasses. Grasslands occur in environments conducive to the growth of this plant cover but not to that of taller plants, particularly trees and shrubs.

Wetland:

A wetland is an area of very wet, muddy land with wild plants growing in it.

A low-lying area of land that is saturated with moisture, especially when regarded as the natural habitat of wildlife.

Landforms

Landforms are **features on the Earth's surface that make up the terrain**, such as mountains, valleys, plains or plateaux. They also include coastal features, such as peninsulas or bays, and underwater features, such as ocean basins and mid-ocean ridges.

Landforms are categorized by characteristic physical attributes such as elevation, slope, orientation, stratification, rock exposure, and soil type.

Gross physical features or landforms include intuitive elements such as berms, mounds, hills, ridges, cliffs, valleys, rivers, peninsulas, volcanoes, and numerous other structural and size-scaled (e.g. ponds vs. lakes, hills vs. mountains) elements including various kinds of inland and oceanic water bodies and sub-surface features. Mountains, hills, plateau, and plains are the four major types of landforms. Minor landforms include buttes, canyons, valleys, and basins. Tectonic plate movement under the Earth can create landforms by pushing up mountains and hills.

Types of Landforms



Examples in India landform

- The Great mountains through Sikkim. ...
- The Thar Desert through Rajasthan. ...
- The Great Northern Plains through Delhi. ...
- The Peninsular Plateau through Maharashtra. ...
- The Coastal Areas and Islands through Andaman and Nicobar Islands

Conservation of Landforms

While landforms don't easily just disappear, their state can be jeopardized by human activities like deforestation, agriculture, development, pollution, and overuse. Protecting landforms from these burdens preserves their ecological and economic value, and ensures they can be enjoyed by generations to come.



We Can Protect Natural Land Formations from Damage, Landforms are natural features of any landscape that can be in the form of valleys, plateaus, mountains, plains, hills and glaciers. These physical features make our planet a better place as you get to witness some majestic scenes while visiting these formations. Protecting them is our responsibility, but with climate change and the amount of damage done by humans, these formations won't be the same as they used to be.

Let's look at 6 ways you can protect natural land formations from damage.

- **Slope Protection:** Among natural landforms, slopes are consistently on the verge of shifting as they have to fight erosive forces. Whether it's a slope that's been formed recently

or it's been there naturally, they all need protection from erosion. The goal should be to increase the soil's resistance to erosion that will slow down the process by not letting the shape change in any form. You need to choose the slope protection system carefully, as all slopes will differ and some may require more advanced systems. The goal isn't only to prevent it from eroding, but also to make slopes more sustainable.

- **Glacier Protection:**



The structure of glaciers is consistently changing as they are melting rapidly, not only affecting human habitats, but directly impacting penguins, mountain goats and bighorn sheep. Animals in the surrounding areas are struggling to survive as the melting glaciers are causing sea levels to rise, giving them less land to live on. Another reason why glaciers are highly important is that they help in providing a shield to mountains, protecting them from erosion. As humans, we need to pay more attention to global warming and think of alternative methods to produce energy that won't heat up our environment.

- **Cave Protection:**



Littering in caves is a major problem. It may seem like there's an obvious solution to it, but worldwide we have seen that littering is on the rise. There's a need for regular clean ups and the level of littering is consistently increasing. The garbage that decomposes can make the cave smell unpleasant and can cause harm to any animals/creatures living inside. People should still be allowed to explore caves, but at the same time they should protect and respect them.

- **Riverbank Protection:**



Riverbanks are important for the ecosystem as they support a variety of animals. Natural riverbank erosion is part of nature, but humans have expedited the process by taking that to an unnatural level. A great way of protecting riverbanks is by making sure sufficient vegetation is available around the banks. Grasses, ground covers, shrubs and trees protect the soil from eroding. If the bank is steep, geotextile fabric should be placed for vegetation.

- **Wetland Protection:**



Why protect wetlands? These areas are where water covers soil. Wetlands are important for our ecosystem as they protect and improve the overall water quality. They also protect fish and other wildlife, store floodwaters and maintain water surface through dry periods. A good way of protecting wetlands is by cordoning off the perimeter. It's also important to educate tourists so they understand the importance of the preservation of wetlands.

- **Forest Protection:**

When you think of a forest, the Amazon must come to your mind instantly. It's an area that many people would love to visit, but sadly due to the speed at which we are destroying them, the next generation will likely never get to see them in their true glory. In order to prevent damage to our forests and rainforests, we should try to prevent floods from getting to the mainland. We also need to improve the quality of air as all living habitats, including engendered species, are currently living in those environments. It is our moral obligation to preserve and protect all land from damage. Sometimes it may be out of our hands, as Mother Nature can be hard to handle. But it's in our best interest to protect land formations as best as we can if we want to have better quality water for our future generations and a beautiful place to live.

LAND CONSERVATION

Land conservation is the process of protecting natural land and returning developed land to its natural state. Due to the fact that some land has only had minor disturbances and other land has been completely destroyed, a variety of techniques are needed to carry out land conservation.

Some common types of land conservation are:

- **Protected Areas:** These are designated regions managed for conservation purposes, such as national parks, wildlife refuges, and nature reserves. They often have legal protections and management plans in place to safeguard their ecological value.

- **Easements:** Conservation easements are legal agreements between landowners and conservation organizations or government agencies. Landowners voluntarily limit certain uses of their property to protect its conservation values, such as preventing development or maintaining habitat.

- **Land Trusts:** Nonprofit organizations known as land trusts work to conserve land by acquiring and managing properties, negotiating easements, and providing technical assistance to landowners. They often collaborate with government agencies, private donors, and communities to protect natural areas.

- **Conservation Leases:** Landowners can enter into agreements with conservation organizations or agencies to lease their land for conservation purposes. This allows for temporary protection of habitat or agricultural land while providing income to the landowner.

- **Conservation Development:** This approach integrates conservation principles into land development projects. Developers set aside a portion of the land as protected open space, preserving critical habitats, scenic landscapes, and recreational areas while still allowing for sustainable development.

- **Community Conservation:** Community-based conservation initiatives involve local residents, stakeholders, and organizations in protecting and managing natural areas. These efforts often focus on education, advocacy, and sustainable land use practices within communities.

- **Forest Conservation:** Strategies for conserving forests include establishing protected areas, implementing sustainable forestry practices, promoting reforestation and afforestation, and combating illegal logging and deforestation.

- **Farmland Preservation:** Agricultural conservation programs aim to protect farmland from conversion to non-agricultural uses. This can involve purchasing development rights,

implementing zoning regulations, and providing incentives for farmers to adopt conservation practices.

□ **Watershed Protection:** Watershed conservation efforts focus on preserving the land surrounding rivers, lakes, and other water bodies to maintain water quality, prevent erosion, and protect aquatic habitats. This often involves land acquisition, restoration projects, and pollution reduction measures.

□ **Conservation Banking:** In conservation banking, landowners can generate revenue by restoring or enhancing habitats on their property and selling "credits" to developers or other entities required to offset their environmental impacts. This incentivizes landowners to conserve and restore habitat while allowing for limited development elsewhere.

Deforestation:

Deforestation or forest clearance is the removal of a forest or stand of trees from land that is then converted to non-forest use. Deforestation can involve conversion of forest land to farms, ranches, or urban use. The most concentrated deforestation occurs in tropical rainforests. Deforestation is the purposeful clearing of forested land. Throughout history and into modern times, forests have been razed to make space for agriculture and animal grazing, and to obtain wood for fuel, manufacturing, and construction. Deforestation has greatly altered landscapes around the world.

Today, the greatest amount of deforestation is occurring in tropical rainforests, aided by extensive road construction into regions that were once almost inaccessible. Building or upgrading roads into forests makes them more accessible for exploitation. Slash-and burn agriculture is a big contributor to deforestation in the tropics. With this agricultural method, farmers burn large swaths of forest, allowing the ash to fertilize the land for crops. The land is only fertile for a few years, however, after which the farmers move on to repeat the process elsewhere. Tropical forests are also cleared to make way for logging, cattle ranching, and oil palm and rubber tree plantations.



This Is What It Will Take to End Deforestation by 2030

Nations around the world made a vital climate crisis declaration to save forests within the next decade. Can they actually do it?

- Deforestation can result in more carbon dioxide being released into the atmosphere. That is because trees take in carbon dioxide from the air for photosynthesis, and carbon is locked chemically in their wood. When trees are burned, this carbon returns to the atmosphere as carbon dioxide. With fewer trees around to take in the carbon dioxide, this greenhouse gas accumulates in the atmosphere and accelerates global warming.
- Deforestation also threatens the world's biodiversity. Tropical forests are home to great numbers of animal and plant species. When forests are logged or burned, it can drive many of those species into extinction. Some scientists say we are already in the midst of a mass-extinction episode.
- More immediately, the loss of trees from a forest can leave soil more prone to erosion. This causes the remaining plants to become more vulnerable to fire as the forest shifts from being a closed, moist environment to an open, dry one.
- Forest is burned or cut for clearing of land for agriculture, harvesting for wood and timber, development and expansion of cities. These economic gains are short term whereas long-term effects of deforestation are irreversible,
 - Deforestation rate is relatively low in temperate countries than in tropics If present rate of deforestation continues, we may losses 90% tropical forest in coming six

decades.

- For ecological balance 33% area should be under forest cover but our nation has only 20.6% forest cover.

Causes of deforestation

Forest area in some developed area has expanded. However in developing countries area under forest is showing declining trend particularly in tropical region. Main causes of deforestation are

a) Shifting cultivation or jhum cultivation

This practice is prevalent in tribal areas where forest lands are cleared to grow subsistence crops. It is estimated that principle cause of deforestation in tropics in Africa, Asia and tropical America is estimated to be 70, 50, and 35% respectively. Shifting cultivation which is a practice of slash and burn agriculture are possess to clear more than 5 lakh hectares of land annually. In India, shifting cultivation is prevalent in northeast and to limited extent in M.P, Bihar and Andhra Pradesh and is contributing significantly to deforestation

b) Commercial logging

It is an important deforestation agent. It may not be the primary cause but definitely it acts as secondary cause, because new logging lots permits shifting cultivation and fuel wood gatherers access to new logged areas.

c) Need for fuel wood

Increased population has lead to increasing demand for fuel wood which is also acting as an important deforestation agent, particularly in dry forest.

d) Expansion for agribusiness

With the addition of cash crops such as oil palm, rubber, fruits and ornamental plants, there is stress to expand the area for agribusiness products which results in deforestation.

e) Development projects and growing need for food

The growing demand for electricity, irrigation, construction, mining, etc. has lead to destruction of forest. Increased population needs more food which has compelled for

increasing area under agriculture crops compelling for deforestation.

f) Raw materials for industrial use

Forest provides raw material for industry and it has exerted tremendous pressure on forest. Increasing demand for plywood for backing has exerted pressure on cutting of other species such as fir to be used as backing material for apple in J&K and tea in northeast states.

Major effects of deforestation

Deforestation adversely and directly affects and damages the environment and living beings .

Major causes of deforestation are

- Soil erosion and loss of soil fertility
- Decrease of rain fall due to effect of hydrological cycle
- Expansion of deserts
- Climate change and depletion of water table
- Loss of biodiversity, flora and fauna
- Environmental changes and disturbance in forest ecosystems.

HOW TO AVOID DEFORESTATION:

- The best way to stop deforestation is replanting.
- Ban on cutting of trees and new trees and planting more.
- There should be an implementation of regulations of laws at organizational and governmental levels due to the extent of deforestation.
- Spread the awareness about sensitization and organize educative campaigns about the effects of deforestation.

Effect of land use changes:



Land use and land cover changes have significant environmental consequences at local, regional, and global scales. These changes have intense implications at the regional and global scales for global loss of biodiversity, distresses in hydrological cycles, increase in soil erosion, and sediment loads. Land use changes occur constantly and at many scales, and can have specific and cumulative effects on air and water quality, watershed function, generation of waste, extent and quality of wildlife habitat, climate, and human health.

EPA is concerned about different land use activities because of their potential effects on the environment and human health. Land development and agricultural uses are two primary areas of concern, with a wide variety of potential effects.

Land Development:

- Land development creates impervious surfaces through construction of roads, parking lots, and other structures.
- Impervious surfaces: Contribute to nonpoint source water pollution by limiting the capacity of soils to filter runoff.
- Affect peak flow and water volume, which heighten erosion potential and affect habitat and water quality.
- Increase storm water runoff, which can deliver more pollutants to water bodies that residents may rely on for drinking and recreation.¹ Storm runoff from urban and suburban areas contains dirt, oils from road surfaces, nutrients from fertilizers, and various toxic compounds.
- Affect ground water aquifer recharge.
- Point source discharges from industrial and municipal wastewater treatment facilities can contribute toxic compounds and heated water.
- Some land development patterns, in particular dispersed growth such as “suburbanization,” can contribute to a variety of environmental concerns.

For example:

- Increased air pollution due to vehicle use results in higher concentrations of certain air pollutants in developed areas that may exacerbate human health problems such as asthma.
- Land development can lead to the formation of “heat islands,” domes of warmer air over urban and suburban areas that are caused by the loss of trees and shrubs and the absorption of more heat by pavement, buildings, and other sources. Heat islands can affect local, regional, and global climate, as well as air quality.

Agricultural Uses:

Agricultural land uses can affect the quality of water and watersheds, including:

- The types of crops planted, tillage practices, and various irrigation practices can limit the amount of water available for other uses.
- Livestock grazing in riparian zones can change landscape conditions by reducing stream bank vegetation and increasing water temperatures, sedimentation, and nutrient levels.
- Runoff from pesticides, fertilizers, and nutrients from animal manure can also degrade water quality.
- Agricultural land use may also result in loss of native habitats or increased wind erosion and dust, exposing humans to particulate matter and various chemicals.
- Some land uses can accelerate or exacerbate the spread of invasive species.

For example:

- Certain agricultural land use practices, such as overgrazing, land conversion, fertilization, and the use of agricultural chemicals, can enhance the growth of invasive plants.
- These plants can alter fish and wildlife habitat, contribute to decreases in biodiversity, and create health risks to livestock and humans.
- Introduction of invasive species on agricultural lands can reduce water quality and water availability for native fish and wildlife species.
- Research is beginning to elucidate the connections between land use changes and infectious disease. For example, some studies indicate that spread of vector-borne disease may be influenced by land use and/or other environmental change.
- Other studies indicate that fragmentation of forest habitat into smaller patches separated by agricultural activities or developed land increases the “edge effect” and promotes the interaction among pathogens, vectors, and hosts.
- In some cases, changes in land use may have positive effects, such as increasing habitat (as a result of deliberate habitat restoration measures) and reclamation of previously contaminated lands for urban/suburban development.

ROE (Report on Environment) Indicators:

The ROE presents two indicators providing information about land use trends: Land Use and Urbanization and Population Change. Available indicators in this area are limited because numerous circumstances (including lack of data; varying approaches to data classification and management, and difficulty in delineating land use) create significant challenges and limitations in tracking trends in and effects of land use.

Lack of data:

There is a general lack of comprehensive data on the types and rates of land use and land cover change, and even less systematic evidence on the causes and consequences of these changes. On a global scale, the National Research Council identified land use dynamics as one of the grand challenges for environmental research.

- No indicators are available to assess the effects that trends in land use have on human health, as effects have not been shown or quantified on a national basis. Researchers have conducted site-specific studies on individual land uses, but little is known about overall national trends in land use and potential impacts on human health.
- An additional challenge is that a variety of state and local laws, regulations, and practices govern the use of land. There are few state-level efforts to organize land use data; most activities occur over specific local, usually urbanizing, geographic areas.
- This means that land use records are not maintained statewide or nationally, as they are in other nations. This contributes to challenges in tracking and monitoring land use changes. It also means that efforts to coordinate land use across jurisdictions are difficult to develop.
- Varying approaches to data classification and measurement: Estimates of the extent of various land uses differ across data sources, and each source uses different classifications, measurement approaches, methodologies for analysis and interpretation, and sampling time frames. The data are collected by many different agencies that manage land for many different purposes.
- Some data collection efforts arise out of specific interests, such as tracking changes in the extent of agricultural land or farmland, or understanding how much land is used for timber production. These data collection efforts tend to develop their own classifications and categorization, making it difficult to integrate the data over time, across inventories, or as a national picture.
- Difficulty in delineating land use: Finally, the difficulty of actually delineating land use presents a challenge in developing data to determine trends. Land use is generally a function of laws, policies, or management decisions that may not always be possible to infer by examining the ground via surveys. Analysis of zoning maps or property records at the local level may be necessary to understand land use.

Land use change:

The most damaging change in land use is demonstrated by the rapidity with which forests have vanished during recent times, both in India and in the rest of the world. Forests provide us with

variety of services. These include processes such as maintaining oxygen levels in the atmosphere, removal of carbon dioxide, control overwater regimes, and slowing down erosion and also produce products such as food, fuel, timber, fodder, medicinal plants, etc. In the long-term, the loss of these is far greater than the short-term gains produced by converting forested lands to other uses.

Land degradation:

It is a process of deterioration of soil or loss of fertility. Due to increasing population, the demands for arable land for producing food, fiber and fuel wood is also increasing. Hence there is more and more pressure on the limited land resources which are getting degraded due to over-exploitation. Nearly 56% of total geographical area of the country is suffering due to land resource degradation. Out of 17-million-hectare canal irrigated area, 3.4 million hectares is suffering from water logging and salinity.

Effects of land degradation:

- Soil texture and soil structure are destructed.
- Loss of soil fertility.
- Loss of valuable nutrients.
- Increase in water logging, salinity, alkalinity and acidity problem.
- Loss of economic social and biodiversity.

Causes of land degradation:

- **Population:** More land is needed for producing food, fiber and fuel wood. So land is degraded due to over exploitation.
- **Urbanization:** Urbanization reduces the agricultural land. Urbanization leads to deforestation, which in turn affects millions of plants and animals.
- **Fertilizers and pesticides:** It affect fertility of the soil and causes land pollution.
- **Damage of top soil:** Increase in food production generally leads to damage of top soil through nutrient depletion.
- Water logging, soil erosion, salination and contamination of the soil with industrial wastes and cause land degradation.

Soil Erosion:

Soil Erosion is the process, in which the soil particles are loosened or washed away in the valleys, oceans, rivers, streams or faraway lands. Soil erosion is a non-stoppable process that occurs either slowly or at a higher rate.

“Soil Erosion is the displacement of the upper layer of soil, one form of soil degradation. The natural process is caused by the dynamic activity of erosive agents, that is, water, ice, snow, air, plants, animals and humans.”

CAUSES OF SOIL EROSION

- **Flooding due to heavy rainfall:** The high intensity of rainfall causes soil erosion. There are four types of soil erosion due to rainfall: Sheet erosion, Splash erosion, Rill erosion, and Gully erosion. Eroded soil washed away into the nearby streams and rivers due to the high amount of rainfall. The higher the amount of Rainfall higher will be the soil erosion.
- **Agricultural activities:** Another main cause of soil erosion is farming practices, they disturb the ground. The trees are cut down and the lands are plowed for the germination of new seeds. Most crops are grown during springs and most of the soil is eroded during winters because the land lies fallow during winters.
- **Grazing:** The grazing animals remove the plants or vegetation from the land through their feeding habit at a place. The only left is topsoil. They also pull out plants by their roots, due to which soil loosens up and more erosion will occur.
- **Mining:** In the Mining process, a large number of trees were cut down to make the field fit for logging, due to which soil get loose and erosion occur in a frequent manner.
- **Constructional activities:** The construction also leads to soil erosion. for construction purposes, the forests and grasslands are cleared which exposes the soil making it more favorable to erosion

Prevention of Soil Erosion

This is a serious environmental issue. Steps should be taken to reduce this problem. There are various listed methods for prevention:

- Planting trees on barren lands, through these roots can hold soil tightly to limit erosion of soil.
- Erosion on the slopes can be reduced with Mulch matting.

- Put a series of fibre cloth logs to prevent any water or soil from washing away.
- At the base of the slope, the building wall can stop the eroded layer to flow down.
- The proper drainage systems in every household can lead to water flowing down into proper water collecting systems.
- Terrace cultivation leads to the reduction of soil erosion, this practice is done in the Western and Central Himalayas.
- Strip Cropping – When a large field is divided into strips and strips of grass are left to grow between the crops. Then, this breaks up the force of the wind. This method is known as Strip Cropping.

Types of Soil Erosion

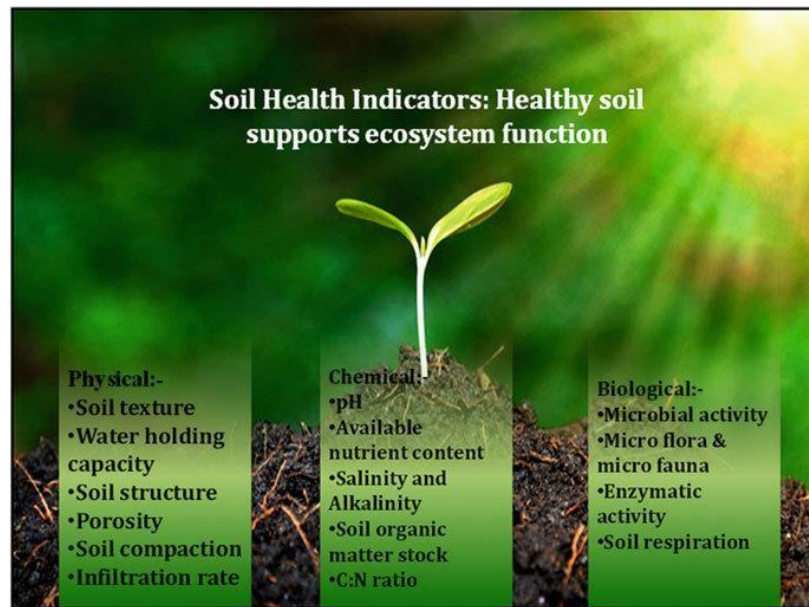
The thing that we can do to improve the stability or quality of our crops is to reduce soil erosion. Different forms of soil erosion are as:

- 1. Rain Drop or Splash Erosion:** This kind of erosion is caused due to falling rainfall or raindrops over a soil surface which may cause the structure of the soil to be known as raindrop or splash erosion.
- 2. Rill Erosion:** This kind of erosion, basically, is water erosion in which the erosion takes place when the water forms small channels or streams in the soil as it flows off-site. It is the most common form of erosion, It observes during heavy rain.
- 3. Sheet Erosion:** When a high amount of wind travels over the lands or fields that lead to the removal of soil in thin layers. Land areas with loose topsoil have greater chances to come under the category of sheet erosion.
- 4. Gully Erosion:** Gully erosion occurs due to the removal of soil along drainage lines by surface water runoff. Gully Erosion in India is most commonly found in the states of Madhya Pradesh, Uttar Pradesh, Gujarat, West Bengal, and Rajasthan.

Soil health:

Soil health is the condition of the soil in a defined space and at a defined scale relative to a set of benchmarks that encompass healthy functioning. It would not be appropriate to refer to soil health for soil-roadbed preparation, as in the analogy of soil quality in a functional class. The definition of soil health may vary between users of the term as alternative users may place differing priorities upon the multiple functions of a soil. Therefore, the term soil health can only be understood within the context of the user of the term, and their aspirations of a soil, as well as by the boundary definition of the soil at issue. Finally, intrinsic to the discussion on soil health are many potentially conflicting interpretations, especially ecological landscape assessment vs agronomic objectives, each claiming to have soil health

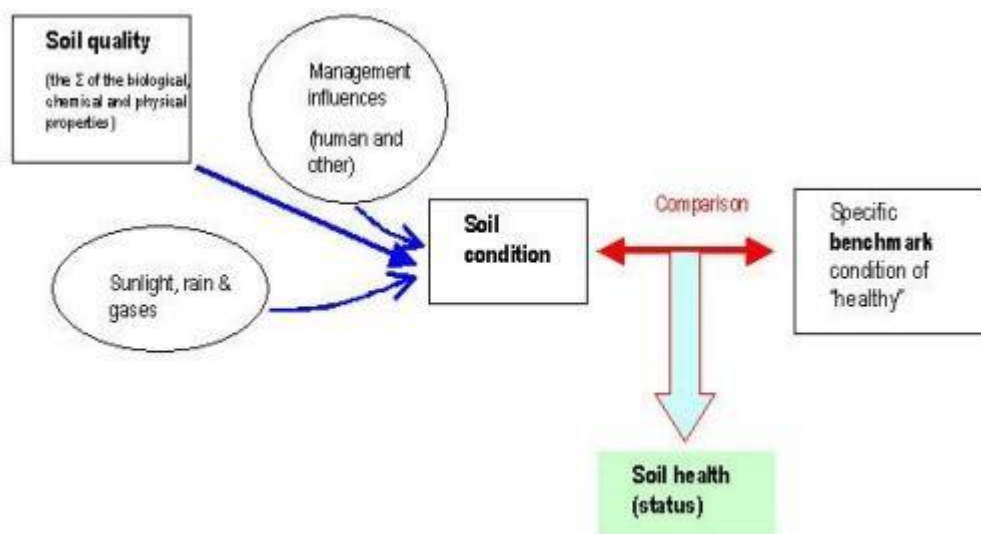
criteria.



Different soils will have different benchmarks of health depending on the “inherited” qualities, and on the geographic circumstance of the soil.

The generic aspects defining a healthy soil can be considered as follows:

- ☐ “Productive” options are broad
- ☐ Life diversity is broad
- ☐ Absorbency, storing, recycling and processing is high in relation to limits set by climate
- ☐ Water runoff quality is of high standard
- ☐ Low entropy and
- ☐ No damage to or loss of the fundamental components.



The USDA Natural Resources Conservation Service (NRCS) has identified four principles for improving soil health and sustainability:

1. Use plant diversity to increase diversity in the soil.
2. Manage soils more by disturbing them less.
3. Keep plants growing throughout the year to feed the soil.
4. Keep the soil covered as much as possible.
5. Integrate livestock to recycle nutrients and increase plant diversity.

A healthy soil has good water infiltration and retention. The biological activity within the soil increases soil fertility and helps build good soil structure. These things reduce the need for expensive inputs and increase plant resilience to drought, pests and intense rains.

This translates to:

- ☐ A comprehensive cover of vegetation
- ☐ Carbon levels relatively close to the limits set by soil type and climate
- ☐ Little leakage of nutrients from the ecosystem
- ☐ Biological and agricultural productivity relatively close to the limits set by the soil environment and climate
- ☐ Only geological rates of erosion

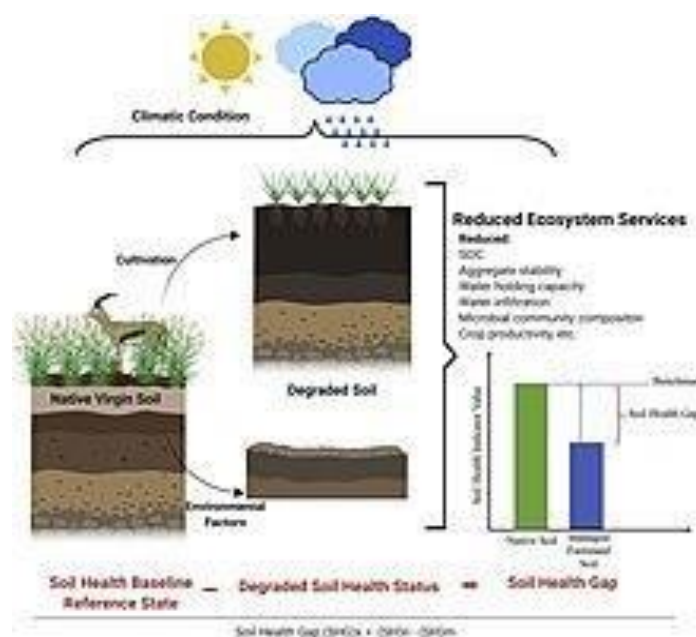
□ No accumulation of contaminants and an unhealthy soil thus is the simple converse of the above.

The term soil health is used to describe the state of a soil in:

- Sustaining plant and animal productivity (agronomic focus)
- Enhancing biodiversity (Soil biodiversity) (ecological focus)
- Maintaining or enhancing water and air quality (environmental/climate focus)
- Supporting human health and habitation.
- Carbon sequestering.

SOIL HEALTH GAP

- ❖ Importance of soil for global food security, agro-ecosystem, environment, and human life has exponentially shifted the trends of research towards soil health.
- ❖ However, lack of a site/region specific benchmark has limited the research effort towards understanding the true effect of different agronomic managements on soil health.
- ❖ In 2020, Maharjan and his team, introduces a new term and concept "Soil Health Gap" and described how native land in particular region can help in establishing the benchmark to compare the efficacies of different management practices and at the same time it can be used in understanding quantitative difference in soil health status.



Ecological and economic importance of soil:

Soil provides ecosystem services critical for life: soil acts as a water filter and a growing medium; provides habitat for billions of organisms, contributing to biodiversity; and supplies most of the antibiotics used to fight diseases. Humans use soil as a holding facility for solid waste, filter for wastewater, and foundation for our cities and towns. Finally, soil is the basis of our nation's agro ecosystems which provide us with feed, food and fuel.

Ecological importance of soil:

Advances in watershed, natural resource, and environmental sciences have shown that soil is the foundation of basic ecosystem function. Soil filters our water, provides essential nutrients to our forests and crops, and helps regulate the Earth's temperature as well as many of the important greenhouse gases. As our awareness of the value of natural and managed ecosystems services grows, new biodiversity, carbon, and water markets are emerging, such as the Chicago Climate Exchange, and the nutrient trading programs under the new Executive Order on the Protection and Restoration of the Chesapeake Bay. These markets place an economic value on management practices which increase those ecosystem services, producing goods that enhance human and environmental health.

Economic importance of soil

- Soil plays a crucial role in the economy of countries. Farming and agricultural industries are probably the most reliant upon soil, particularly in respect to crop production, which has risen dramatically in the last 50 years in order to cope with the demands of an equally rapidly growing global population.
- The demand for more crops has increased the demand for plant nutrients in the form of fertilisers. For a long time, many farms relied on animal manure for this. However most farms in the west now use artificial fertilisers, because it allows more control over which nutrients should be applied to the soil and when.
- In the developed countries of the world it has been possible to increase the productivity of soils immensely because of the introduction and development of such fertilisers. For example, the use of nitrogen fertilisers has increased 15-fold in the UK in the last 50 years, and over the same period yields of some crops have trebled. Research conducted into crop growth, and how soils release nutrients to plants, has enabled farmers to use suitable and better adapted fertilisers for different crops and soils, and thus add to the fertility of their soils.

□ There are many other economic land uses that are dependent on the soil, particularly forestry. Trees are usually longer term 'crops' in which an important relationship is built up with the soil to establish a nutrient balance.

Impact of soil degradation on agriculture and food security:

Soil degradation is the physical, chemical and biological decline in soil quality. It can be the loss of organic matter, decline in soil fertility, and structural condition, erosion, adverse changes in salinity, acidity or alkalinity, and the effects of toxic chemicals, pollutants or excessive flooding. Soil degradation can involve:

- Water erosion (includes sheet, rill and gully erosion)
- Wind erosion
- Salinity (includes dry land, irrigation and urban salinity)
- Loss of organic matter
- Fertility decline
- Structure decline (includes soil compaction and surface sealing)
- Mass movement
- Soil acidity /alkalinity
- Soil contamination (including effects of toxic chemicals and pollutants).

Impact of soil degradation on agriculture:

- The effects of soil erosion go beyond the loss of fertile land.
- It has led to increased pollution and sedimentation in streams and rivers, clogging these waterways and causing declines in fish and other species. And degraded lands are also often less able to hold onto water, which can worsen flooding.
- Because soil degradation contributes to land degradation, it also means that it creates a significant loss of arable land. As stated earlier, about 40% of the world's agricultural land is lost on the account of soil quality depreciation caused by agrochemicals and soil erosion.
- Most of the crop production practices result in the topsoil loss and the damage of soil's natural composition that makes agriculture possible.
- Most of the area under cultivation in India has been under cultivation for hundreds of years, and had reached its state of maximum impoverishment many years ago. In this connection it

must be Sustainability remembered that deficiency of combined nitrogen is the limiting factor throughout the greater part of India”.

□ The Green Revolution brought about a technological breakthrough, leading to the use of short duration high yielding varieties that helped intensify land use within a year by increasing the area under irrigation and greatly increasing the use of chemicals such as fertilizers and pesticides. Agricultural production of India increased from 50 Mt to over 250 Mt, over the last five decades. This, however, had further consequences, including loss of plant biodiversity and environmental pollution.

□ Widespread land degradation has a direct and adverse impact on the food and livelihood security of farmers. Basically, degradation is caused by erosion, which results in the loss of topsoil through the action of water and wind, or waterlogging, which results in soil salinization.

□ Sustainability of agricultural production systems depends on their carbon (C) footprint and the C output-input ratio.

□ The C-sustainability index was high in 1960, and was indicative of the minimum usage of inputs prior to the onset of the Green Revolution.

□ Thereafter, the C-sustainability index decreased because of greater C-based inputs, in which a linear relationship exists between C inputs and C outputs. In converse Agricultural activities and practices can cause land degradation in a number of ways depending on land use, crops grown and management practices adopted.

Impact of soil degradation on food security:

Soil degradation, poses a threat to food security, as it reduces yield, forces farmers to use more inputs, and may eventually lead to soil abandonment.

□ Soils constitute the foundation for agricultural development, essential ecosystem functions and food security and hence are key to sustaining life on Earth that get disturbed.

□ Experts warn us that addressing the stagnating yields of our most important croplands is of paramount importance; failure to identify and alleviate the causes of yield stagnation, or reduction, will have a major impact on the future of global food security. Many issues, including yield reduction, have coalesced to determine agricultural trends in recent decades (e.g., population pressure, water supply, markets, policies, climate).

- Soil degradation is causing a decline in crop productivity and huge economic. Sustainability loss, putting the food security and livelihood of farmers at risk need for soil conservation sustainable land use planning.
- The overall effects of soil degradation pose a major threat to food security especially in poor regions. FAO (The Food and Agriculture Organization of the United Nations) highlights that there is a strong relation between land degradation and poverty. It is urgent, therefore, to act to halt soil degradation and adopt practices to improve soil health.
- Arable land is regarded as the best and most productive land available; it is generally cropped with cereals or highly profitable crops. Therefore, a reduction in arable land on a per capita basis may affect food production and, most importantly for the poor countries, food security. A reduction in arable land per capita generally forces a country to increase land productivity (increasing the inputs), expand the land used for production (possible marginal land, or converting forests) and/or rely on imports.
- Effective governmental policies should be implemented in order to facilitate the adoption of more, sustainable management practices, for example, by implementing policies that favour the provisioning of ecosystem services. More importantly, agricultural policies should be concerned with guaranteeing food security for people on a long-term scale (access to sufficient amounts of healthy food), taking also into account the potential outcome of extreme events.

Need for soil conservation:

Soil provides the nutrients essential for plant growth, animal life, and millions of microorganisms. However, if soil becomes unhealthy, unstable, or polluted, the life cycle stops. Soil conservation focuses on keeping soils healthy through a combination of practices and techniques. Individuals committed to soil conservation help ensure that soil is fertile and productive, and protect it from erosion and deterioration.

- Soil conservation is important for sustainability. For those working in sustainability, an understanding of soil's role can create opportunities to develop new solutions and promote stewardship of our environment.

Why is soil conservation important for sustainability?

Simply put, without soil conservation, soil erosion would increase. Soil erosion impacts markets worldwide, including \$8 billion in losses due to lower crop yields and increased water usage.

Why is soil important?

Soil is essential to food production. Crops need soil to grow, and farm animals need vegetation for feed. Conserving soil can help address food insecurity and promote healthy communities. Soil also helps to create a cleaner climate, absorbing about a third of the carbon dioxide that fossil fuels and industrial operations emit, according to the Climate Change and Land report from the Intergovernmental Panel on Climate Change (IPCC). Healthy stewardship of soil can help mitigate climate change's impact.

Soils help meet societal needs, providing food, energy, and nutrients. They also help minimize the impact of climate change and promote healthy ecosystems.

Below are three reasons why soil is so important:

➤ Soil is home to many living things Soil organisms ensure sustainable food systems and mitigate climate change. Plants and animals rely on soils for food, shelter, and more. Soil is also home to fungi, algae, and unicellular and multicellular organisms that are invisible to the naked eye, such as bacteria and protozoa. As they move through the soil, microorganisms help improve drainage and soil structure, making soil more fertile and productive.

➤ **Soil is key to the carbon cycle:** Soil plays a critical role in the carbon cycle: the continuous process by which carbon atoms travel between the atmosphere and Earth. For example, in breaking down organic matter in the soil, microorganisms release carbon dioxide into the atmosphere and create nutrients and minerals that feed plants and crops. Soil also naturally absorbs carbon from the atmosphere in a process known as sequestration. Healthier soil absorbs more carbon, reducing the effects of greenhouse gases.

➤ **Soil's essential role:**

Farmers rely on soils to make food production possible, feeding people and livestock. Soil also acts as a purifier: As surface water travels through the ground to replenish aquifers, soil filters out toxins and impurities, making it drinkable. Soil also provides raw materials for infrastructure.

For example, soil is an important element in making bricks for buildings. For many, soils are simply dirt – something to keep out of sight and out of mind – and yet soils play a substantial role in our everyday lives. Each year, soils support food production, purify our

water, and provide raw materials for buildings and infrastructure. As a result, our soils are a critical resource for tackling many of the 17 identified UN Sustainable Development Goals,

including food security, clean water and sanitation, and good health and wellbeing. Soils also serve as the habitat for billions of organisms. A teaspoon of soil contains more microorganisms than there are people on the planet! Part of the reason why there is so much life in soils is because of soil organic carbon. This carbon helps to provide energy for the growth of microorganisms, and to promote the formation of new cells.

“a teaspoon of soil contains more microorganisms than there are people on the planet”.

But the significance of soil carbon extends beyond energy supply. It can also help to abate climate change. Our soils contain 1,500 billion tons of carbon, representing more than that found in the atmosphere and plants combined. In fact, plants have taken up approximately a quarter of the carbon dioxide emissions that humans have released into the atmosphere. When plants absorb carbon dioxide, it is initially converted into a food resource. However, when these plants die, they decompose into organic matter, transferring this carbon into the soil.

➤ **Soil is on the move:**

Soils face burgeoning demands. By 2050, the global population is estimated to soar to more than nine billion, potentially reaching eleven billion by the close of the century. Soils will need to provide more food, clean water and raw materials. These challenges are exacerbated by the fact that over a third of global soil resources are currently either moderately or highly degraded. Each year, about 60 billion tons of topsoil are eroded globally. Much of this is human-induced, or „accelerated“: the use of conventional, intensive agricultural techniques reduces the soil’s resistance to erosion.

NEED/IMPORTANCE OF SOIL CONSERVATION

- ☐ Soils are critical for the existence of life on earth. Plants grow on soils, and they are a source of food for both man and animals. Moreover, the soil is the primary habitat for many organisms.
- ☐ Soils help in the percolation of water and maintain groundwater levels. If soil would not have been there, recharging groundwater would be difficult, and we would have faced water shortage.
- ☐ Soils also act as a natural filtration system for surface water. They absorb all the impurities and leave behind fresh, pure water on the surface for our use.
- ☐ Soils have a major role in maintaining the climate of the Earth; they are the second largest carbon sink after oceans. Carbon dioxide is stored in the soil by plants through

the process of photosynthesis. As per some estimates, the carbon pool in soil stands at 2500 billion tonnes.

- ❑ Soils absorb excess rainwater and play an important role in mitigating floods.
- ❑ The fertile alluvial soils of Indo-Ganga Plains and coastal deltaic region support a significant population as it is ideal for practice farming. Moreover, soils also support development and economic growth as all infrastructure stands on soil only.
- ❑ Soil conservation is important as degradation and acidification of soil are permanent phenomena and cannot be reversed. Once we lose an inch of soil, we will never be able to retrieve the same.

SUSTAINABLE LAND USE PLANNING:

Land provides an environment for agricultural production, but it also is an essential condition for improved environmental management, including source/sink functions for greenhouse gasses, recycling of nutrients, amelioration and filtering of pollutants, and transmission and purification of water as part of the hydrologic cycle. The objective of sustainable land management (SLM)¹ is to harmonise the complimentary goals of providing environmental, economic, and social opportunities for the benefit of present and future generations, while maintaining and enhancing the quality of the land (soil, water and air) resource (Smyth and Dumanski, 1993). Sustainable land management is the use of land to meet changing human needs (agriculture, forestry, conservation), while ensuring long-term socioeconomic and ecological functions of the land.



Sustainable land management combines technologies, policies, and activities aimed at integrating socioeconomic principles with environmental concerns, so as to simultaneously:

- ☐ maintain and enhance production (productivity)
- ☐ reduce the level of production risk, and enhance soil capacity to buffer against degradation processes (stability/resilience)
- ☐ protect the potential of natural resources and prevent degradation of soil and water quality (protection)
- ☐ be economically viable (viability)
- ☐ be socially acceptable, and assure access to the benefits from improved land management (acceptability/equity).

Principles and criteria for sustainable land management:

Experiences gained from field projects in developing and developed countries have identified a series of principles (lessons learned) for sustainable land management, and these can be used as general guidelines for development projects (Dumanski, 1994; 1997; World Bank, 1997). The most useful of these are summarised below:

Global concerns for sustainability:

Sustainability can be achieved only through the collective efforts of those immediately responsible for managing resources. This requires a policy environment that empowers farmers and other, local decision makers, to reap benefits for good land use decisions, but also to be held responsible for inappropriate land uses.

Integration of economic and environmental interests in a comprehensive manner is necessary to achieve the objectives of sustainable land management. This requires that environmental concerns be given equal importance to economic performance in evaluating the impacts of development projects, and that reliable indicators of environmental performance be developed.

There is urgent need to resolve the global challenge to produce more food to feed rapidly rising global populations, while at the same time preserving the biological production potential, resilience, and environmental maintenance systems of the land. Sustainable land management, if properly designed and implemented, will ensure that agriculture becomes a part of the environmental solution, rather than remaining an environmental problem.

Sustainable Agriculture

More ecologically balanced land management can achieve both economic and environmental benefits, and this must be the foundation (linch pin) for further rural interventions (investments). Without good land management, other investments in the rural sector are likely to be disappointing. At the same time, arguing for the continued maintenance of agriculture without reference to environmental sustainability is increasingly difficult. Indicators of land quality are needed to guide us along the way.

Agricultural intensification is often necessary to achieve more sustainable systems. This requires shifts to higher value production, or higher yields with more inputs per unit of production and higher standards of management (more knowledge intensive). However, sustainable agriculture has to work within the bounds of nature not against them. Many yield improvements can be achieved by optimizing efficiency of external inputs rather than trying to maximize yields.

The importance of off-farm income should not be underestimated because it,

- i) Supplements cash flow on the farm,
- ii) Generates an investment environment for improved land management, and therefore
- iii) Reduce production pressures on land.

Sharing responsibilities for sustainability

Farmers and land managers must expand their knowledge of sustainable technologies and implement improved procedures of land stewardship. The preferred option is not to tell the farmer what to do (command and control legislation), but to create an enabling environment through policy interventions where farmers are more free to make the right choice. A policy environment where farmers are more empowered, but also held accountable, for achieving the objectives of sustainable land management is essential. However, sustainable land management is the responsibility of all segments of society. Governments must ensure that their policies and programs do not create negative environmental impacts, and society needs to define requirements for land maintenance and develop a "social" discount rate for future land use options that encourages the most sustainable use.

Concerns for sustainable land management go beyond agriculture to include the legitimate interests of other aspects of land stewardship, including wildlife, waterfowl and biodiversity management. There is increasing evidence that society is demanding that farmers become

stewards of rural landscapes, and that agriculture become more than simply putting food on the table. Many of society's environmental values may not represent economic gains for farmers, however, and farmers cannot shoulder all the costs of environmental maintenance.

THE LAND QUALITY INDICATOR (LQI) PROGRAM

- Indicators of land quality (LQIs) are being developed as a means to better coordinate actions on land related issues, such as land degradation. Economic and social indicators are already in regular use to support decision making at global, national and sub-national levels and in some cases for air and water quality, but few such indicators are available to assess, monitor and evaluate changes in the quality of land resources. Land refers not just to soil but to the combined resources of terrain, water, soil and biotic resources that provide the basis for land use.
- Land quality refers to the condition of land relative to the requirements of land use, including agricultural production, forestry, conservation, and environmental management. The LQI program addresses the dual objectives of environmental monitoring as well as sector performance monitoring for managed ecosystems (agriculture, forestry, conservation and environmental management).
- The primary research issue in the LQI program is the development of indicators that identify and characterize the impact(s) of human interventions on the landscape for the major agro ecological zones of tropical, sub-tropical and temperate environments.
- Core LQIs identified for immediate development are: nutrient balance, yield gap, land use intensity and diversity, and land cover; LQIs requiring longer term research include: soil quality, land degradation, and agro-biodiversity.
- LQIs being developed by other authoritative groups include: water quality, forestland quality, rangeland quality, and land contamination/pollution.
- Assessment of sustainable land management requires appropriate evaluation instruments, such as Land Quality Indicators. However, land quality, like the concept of sustainable land management of which it is a part, requires operational definitions and specific, measureable indicators if it is to be more than an attractive, conceptual phrase.
- Core LQIs for managed ecosystems (agriculture and forestry) in the major agro-ecological zones (AEZs) of tropical, sub-tropical and temperate environments, and recommended for development in the short term include.

- Nutrient balance. this describes nutrient stocks and flows as related to different land management systems used by farmers in specific AEZs and specific countries.
- Yield trends and yield gaps. this describes current yields, yield trends, and actual: potential, farm level yields for the major food crops in different countries.
- Land use intensity. describes the impacts of agricultural intensification on land quality. Intensification may involve increased cropping, more value-added production, and increased amounts and frequency of inputs; emphasis is on the management practices adopted by farmers in the transition to intensification.
- Land use diversity (agro-diversity). describes the degree of diversification of production systems over the landscape, including livestock and agro-forestry systems; it reflects the degree of flexibility (and resilience) of regional farming systems, and their capacity to absorb shocks and respond to opportunities.
- Land cover. describes the extent, duration and timing of vegetative cover on the land during major erosive periods of the year. It is a surrogate for erosion, and along with land use intensity and diversity, it will give increased understanding on the issues of desertification.

A second set of core LQIs were recommended for longer-term research. These are indicators which require further development of their theoretical base, or lack adequate data for immediate development⁵. These include:

- Soil Quality. Likely to be based on soil organic matter turn-over, particularly the dynamic (microbiological) carbon pool most affected by environmental conditions and land use change.
- Land degradation (erosion, salinization, compaction, organic matter loss): these processes have been much researched and have a strong scientific base, but reliable data on extent and impacts are often lacking.
- Agro-biodiversity. involves objectives of managing natural habitats and the co-existence of native species in agricultural areas, maintaining natural soil micro and meso biodiversity, and managing the gene pools utilized in crop and animal production.

Four additional sets of core LQIs were identified, but these were recommended to be developed through collaboration with the respective authoritative disciplines:

- Water quality
- Forest land quality
- Range land quality

Land contamination/pollution: The above are the biophysical components of sustainable land management. Although useful in their own right, they must still be complemented with indicators of the other pillars of sustainable land management, economic viability, system resilience, and social equity and acceptability. Considerable additional work is required to develop these pillars to the same level of detail as the land quality (biophysical) indicator.

LAND USE PLANNING PRINCIPLES

- ❖ Evaluate and record unique features.
- ❖ Preserve unique cultural or historical features
- ❖ Conserve open space and environmental features
- ❖ Calculate additional charges for altering land.
- ❖ Plan for mixed uses in close proximity.
- ❖ Plan variety of transportation options.
- ❖ Set limits and manage growth patterns.
- ❖ Encourage development in areas of existing infrastructure.