# UNIVERSITY OF GONDAR

## FACULTY OF SOCIAL SCIENCES AND HUMANITIES

## DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES

## GEOGRAPHY OF NATURAL RESOURCE MANAGEMENT

**(GeES 3101)**

**CREDIT HOUR: 3**

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# Preface

This module is prepared for the summer program which will be given at distance. Geography of natural resource is a course which commonly given for geography major students. The course mainly deals with the major concepts and classification of natural resources. As it applies to soil, natural vegetation, rangeland, wild life, water, and mineral resources, the course addresses definitions, concepts, types, uses, threats and ways of managing and utilizing these resources in the way they can fulfill humans need sustainably. Short summaries as well as check lists and self-test activities are given at the end of each chapter.

**Course Objectives:**

**At the end of the course students will be able to:**

- Develop basic concepts regarding to natural resource management and their conservation.
- Recognize major types of natural resources and describe the nature, classification and association of soil, vegetation, water and mineral resources.
- Assess the impact of man on natural resources.
- Distinguish the cause and consequences of resource degradation and depletion.
- Identify management and conservation strategies that should applied to the conservation of resources.

# CHAPTER ONE

# 1. INTRODUCTION

**Contents:**



**Objectives:**

✧ **Up on the completion of this chapter, learners will be able to:**

- Define natural resource
- Classify natural resources in to different categories based on different criteria
- Describe the need to study natural resources
- Differentiate the major approaches in natural resource management
- Explain values of natural resources
- Explain the basic differences in the Cornucopias and Neo-Malthusians with regard to natural resource management

## 1.1 Definition of Natural Resources

?*Dear learners; what is a natural resources?* (Use the space below for your answer)

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A natural resource is anything we get from the physical environment to meet our needs and wants. Natural resources are resources that are derived from the earth and /or biosphere or atmosphere or hydrosphere and exist independently of human activity. Natural resources are defined by humankind's perceptions and attitudes, wants, technological skills, legal, financial and institutional arrangements as well as by political customs.

A natural resource is a material that comes from the Earth and in its raw or "natural" state is of value for one reason or another. Some examples of natural resources would be oil, timber, and water, as well as a variety of minerals, metals and ores like salt, coal, and metals like gold, iron, and aluminum. Water in a high lake is a natural resource. Even living things and materials like grasslands, forests, herds of animals, flocks of birds, and schools of fish can be considered natural resources.

Natural resources are the things that Earth provides us that we can use, but which must be managed to maintain their viability. Natural resources (economically referred to as land or raw materials) occur naturally within environments that exist relatively undisturbed by mankind, in a natural form. Many of them are essential for our survival while others are used for satisfying our wants. Natural resources are dynamic, becoming available to human being through a combination of increased knowledge and expanding technology as well as changing individual and societal objectives. In short, a resource is a naturally occurring, exploitable material that a society perceives to be useful to its economic and material well-being. The availability of natural resources is a function of two things: the physical characteristics of the resources themselves and human economic and technological conditions.

**Focus**

- *Natural resource can be defined as any part of the natural environment like soil, water, air, mineral, forest, grasslands, range lands, wildlife, etc. that human being utilize to promote life.*

## 1.2 Why We Need to Study Natural Resources?

It has been long time since human being begins studying natural resources for different purpose. The study of natural resource is as long as the age of human being on the earth surface and begun since human being needs to satisfy his wants using the earth's resources.

Currently the study of natural resource is important for a several reasons such as:

- ✓ To identify and classify the current reserves of natural resources
- ✓ For efficient utilization of resources without disturbing the prospects of the future generation.
- ✓ For proper resource management and to develop environmentally sustainable economy. Sustainable development means "is meeting the needs and aspirations of the present generation without compromising the ability of future generations to meet their own needs".
- ✓ To identify the use of minerals
- ✓ Geographers study Natural resources to analyze or to examine the relationship that exist between people and its surrounding materials

## 1.3 Classification of Natural Resources

Classification is a systematic arrangement of things in to groups based on certain common characteristics. Natural resources can be further classified in to different categories based on different parameters.

?*Dear learners; what are the major criteria used to classify natural resources?* (Use the space below for your answer)

1. On the basis of ***origin***, resources can be divided into:

   **A.** ***Biotic*** **-** Biotic resources are obtained from the biosphere, such as forests and their products, animals, birds and their products, fish and other marine organisms. Mineral fuels such as coal and petroleum are also included in this category because they formed from decayed organic matter.

   **B.** ***A biotic*** - A biotic resources include non-living things. Examples include land, water, air and ores such as gold, iron, copper, silver etc.

2. Considering their ***stage of development***, natural resources may be divided in to:

   **A.** ***Potential or speculative Resources*** - Potential resources are those that exist in a region and may be used in the future. For example, petroleum may exist in an area, having sedimentary rocks but until the time it is actually drilled out and put into use, it remains a potential resource.

   **B.** ***Conditional or sub economic resources*** – deposits which have been discovered but which are uneconomical due to current prices and technology.

   **C.** ***Actual Resources or proven resources***- are those that have been surveyed, their quantity and quality determined and are being used in present times. The development of an actual resource depends upon the technology available, need of the society and the cost involved. That part of the actual resource that can be developed profitably with available technology is called a reserve.

3. Classification on the basis of **distribution and volume**. On the basis of their manner of distribution, we can identify the following types of resources.

**A. Ubiquitous Resources (ubiquities**) – these are resources available everywhere like Oxygen, sunlight, sound. Human being can use these resources without fear of exhaustion compared with the other resources.

**B. Common Resources (commonalities**) - these are resources occurring commonly in many places but less wide spread than ubiquitous resources like tillable soil (cultivable soil).

**C. Rare resources (rarities**):- are those occurring in few places/ areas and, therefore, restricted in distribution and volume. There are two types of rarity.

- **Absolute Rarity:** – refers to the step by which the known supply of resources is limited in quantity. Example: Tin, gold etc. These resources are limited physically.
- **Relative Rarity:** - refers to the cost of making a given resource available depending not on physical quantity, but more on other factors like quality of deposit, accessibility, price and technology

**D. Unique Resources (uniquities)**

These are resources which are found only in one place /area e.g. semen fox is found in Ethiopia particularly in Semen Mountains only.

4. Based on their **relation with current use and future availability**, resources can be categorized as **flow** and **stock** resources.
   **A. Flow resources**: in the case of flow resources, there is no link between current use and their future availability. Common examples are that of solar radiation, wind, wave etc.

**B. Stock resources**: are defined by the fact that the level of current use does affect future availability. They are again classified as renewable (biotic population) and non-renewable like minerals and fuels.

?*Dear learners; try to differentiate exhaustible natural resources from inexhaustible ones*.

(Use the space below for your answer)

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**5.**With respect to ***renewability***, natural resources can be categorized as follows:

**1.Exhaustible-** Exhaustible natural resources are resources in which their amount diminishes as used by human beings. Exhaustible natural resources are further classified as renewable and non-renewable resources.

**a. Renewable resources** (flow resources)

Includes all living things that have the capacity for reproduction and growth in long run. As long as the rate of use is less than their rate of regeneration, and as long as their environments are kept, they will go on replacing or replenished themselves.

Renewable resources can be replenished or reproduced easily. A renewable resource grows again or comes back again after we use it.

Many renewable resources can be depleted by human use, but may also be replenished, thus maintaining a flow. Some of these, like agricultural crops, take a short time for renewal; others, like water, take a comparatively longer time, while still others, like forests, take even longer. Classifying something as a renewable resource, however, doesn't mean that it can't be depleted and that it will always stay renewable. The highest rate at which a renewable resource can be used without decreasing its potential for renewal throughout the world or in a particular area is called

its **sustained yield**. If this yield is exceeded, the base supply of a renewable resource begins to shrink. If such unsustainable use continues, the resource can become nonrenewable on a human time scale or sometimes nonexistent – a process known as **environmental degradation**.

**b. Non-renewable resources:**

Non-renewable resources refers to those resources that exist in finite supply and are not being generated at a significant rate in comparison to our use. A non-renewable resource is a resource that does not grow or come back, or a resource that would take a very long time to come back; are formed over very long geological periods. Minerals and fossil fuels are included in this category. Since their rate of formation is extremely slow, they cannot be replenished once they get depleted. Of these, the metallic minerals can be re-used by **recycling** them. **Recycling** involves collecting and re-melting or reprocessing a resource.

For example, aluminum beverage cans can be collected, melted, and converted in to new beverage cans or other aluminum products. **Reuse** involves using a resource over and over in the same form. For example, refillable beverage bottles can be collected, washed and refilled. But coal and petroleum **cannot be recycled**. When we use coal, there is less coal afterward. It is important to conserve (save) non-renewable resources, because if we use them too quickly today there will not be enough in the future.

**2. Inexhaustible-** This category includes natural resources that are essentially continues in time and cannot be significantly altered by human being. Solar energy is a good example of a perpetual resource it will continue to arrive at the earth's surface at reasonably constant rate for the foreseeable future.

## 1.4 Degradation of Natural Resources

The survival of human population, from time immemorial, depends on the use of natural resource that are generally used for economic use, scientific use, health and aesthetic etc. For various reasons the exploitation or extraction of natural resources coupled with lack of proper management

of the environment has resulted for their depletion. Some view this depletion as a major source of social unrest and conflicts in developing nations. Generally speaking, resource depletion occurs;

- When the rate of resource exploitation is faster that the rate it replace itself
- Through unwise use of resources like burning of forests, killing of animals, etc.
- When resource depletion of one type results in a chain of reactions and imbalance of the environment as a whole
- Due to failure to obtain great yield from land without causing damage to the environment.

## 1.5 Values of Natural Resources

In most cases individuals refers to only economic benefits when looking at the value of environmental resources. There are some other values that are attached to environmental resources summing up to five.

1. **Ethical Value or Intrinsic Value**

This is the value of resource unto itself, regardless of its value to humans. This justifies existence of mountain scenery, worm in the wastes etc. If these resources have a right of existing, then high intrinsic value should be ascribed to them. Intrinsic values are eco-centric or environmental oriented. The rest of these are referred to as extrinsic values.

The extrinsic values are the ones which are external to resources own right to exist, refer instead to the resource's ability to provide something for human beings. Such values are anthropocentric (human centered). Extrinsic values are more utilitarian or practical, than intrinsic values and therefore tend to be more widely discussed in political and economic debates on resource management.

2. **Esthetic Value (Aesthetic Value)**

This is the value of resource in making the world more beautiful, more appealing to the senses and generally more pleasant. The value one place on a mountain hike in the cool morning air is an example. Some people place no value to this and would pay northing for it while others find it indispensable.

### 3. Emotional Values

This is the value resource beyond sensory enjoyment. Some people for example develop very strong emotional bonds to certain natural areas or certain animal or plant species. This is sometimes called sense of a ‘‘place’’. Many psychologists consider nature to be important for mental health, especially children.

### 4. Economic Value

This is type of value involved with tangible products that can be bought or sold. For example food, timber, energy etc. Society needs to focus more on long term economic values, which actually provide more income over the long run. The value of resources for tourism, native fruits, or other sustainable products is ultimately much greater than the value of their destructive uses.

### 5. Environmental Service Values

This is the value of resources in providing intangible services that allow humans (and other life) to exist on earth. Plants help to purify air, produce oxygen and plant roots and soil microbes purify water.
Some people put all the five values on all environmental resources. Others put different values on resources like beach etc.

Logging, mining and other types of harvesting that destroy the resources are called ***direct values***. Most environmental problems arise when the resources are appreciated for only their direct

value. Placing only ‘‘direct’’ short term economic value on natural resources artificially ‘‘discount’’ their true value to society and to the future generations.

Environmental service, emotional, esthetic and ethical values are referred to us ***indirect values***, meaning that they are in ways that do not involve direct harvesting or other destruction of the resources. More sustainable uses of resources, such as extractive forestry and ecotourism, will be encouraged and rewarded. As long as only short term values are considered, overuse and exploitation will be encouraged and rewarded.

Incumbent in the resource utilization is sustainability. Thus most often environmental natural resource managers tend to stress on sustainable utilization of resources. This is as crucial to natural resources as it ensures longevity and persistent quality for generations who depend on resource in question.

## 1.6 Approaches to Natural Resources Conservation

Natural resource management refers to the management of natural resources with a particular focus on how management affects the quality of life for both present and future generations. It is similar with the concept of sustainable development, a scientific principle that forms a basis for sustainable global land management and environmental governance to conserve and preserve natural resources. Natural resource management specifically focuses on a scientific and technical understanding of resources and ecology and the life-supporting capacity of those resources. The term Environmental management is also similar to natural resource management. Conservation of natural resources is the major focus of natural capitalism, environmentalism, the ecology movement, and green politics.

### 1. Integrated Natural Resource Management (INRM) Approach

Integrated Natural Resource Management **(**INRM) is an approach to research that aims at improving livelihoods, agro ecosystem resilience, agricultural productivity and environmental services at community, eco-regional and global scales of intervention and impact. In other words, it aims to enhance social, physical, human, natural and financial capital. It does this by helping solve

complex real world problems affecting natural resources in agro ecosystems. Integrated natural resource management (INRM) is an approach to managing resources sustainably by helping resource users, managers, and other stakeholders accomplish their different goals by consciously taking into account, and aiming to reconcile and synergize, their various interests, attitudes, and actions. These goals include increasing production, enhancing food security, creating value, maximizing profitability, minimizing risk, building up and maintaining various natural and other assets, and conserving the natural resource base. As such, INRM is interdisciplinary and multi scaled, encompassing different but linked levels of social and biophysical organization.

There are a number of strategic directions that will facilitate this process:

- ***Merging research and development***: there are persistent complaints from development agents and resource users about researchers not doing practical work. In sustainability science there is a need to have a close relationship between research and development. Researchers can no longer remain exclusively external actors, but need to engage themselves in action research in order to develop appropriate solutions together with natural resources managers. We need an approach to NRM research that is driven by actual problems and based upon shared learning from real-life situations at operational scales.

- ***Setting up a system for adapting and learning***: The technological fixes of today are unlikely to be tomorrow's solutions. Rather, we need to develop a *cadre* of resource managers, who are able to adapt to constantly changing challenges, and we will need to nurture resource systems that are flexible to changing pressures. Therefore, integrated research is more concerned with better decision making, increasing options and resilience, and reconciling conflicting management objectives as a foundation for better management and technological change than with producing technological packages.

- ***Balancing biophysical and socio-economic sciences***: the shift towards greater economic and political analysis in the assessment of environmental degradation may be considered as a welcome shift from geomorphology towards development studies. There is a need to bridge the

knowledge gaps by innovative approaches, which are able to integrate several biophysical and socioeconomic approaches.

## 2. Participatory Approach of Natural Resource Management

Participation can be defined as a process that facilitates dialogue among all actors, mobilizes and validates popular knowledge and skills, supports communities and their institutions to manage and control resources, and seeks to achieve sustainability, economic equity and social justice while maintaining cultural integrity**.**

## 3. Community-Based Natural Resource Management (CBNRM) Approach

? *Dear learners; what is the essence of community based natural resource management.* (Use the space below for your answer)

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Community-based natural resource management (CBNRM) is presented as an alternative to conventional, top-down approaches to natural resource governance. It entails local, place based projects, programs, and policies that have the goal of advancing healthy environments and human communities. Community-based approaches are used to address natural resource problems by requiring action at community level or involving the management of shared resources. In such cases, linked analysis of natural, social and human capital is essential. The analysis and strengthening of social capital and community relations as well as the development of appropriate institutional arrangements for management of natural resources is very crucial. CBNRM gives more room for active involvement of local citizens in natural resource management and its primary objective is to improve livelihoods through sustainable management of natural resources.

## WHAT SHOULD BE DONE? NEO-MALTHUSIANS VERSUS CORNUCOPIANS

There are conflicting views about what the role of people in the world should be, how serious the world's present and projected environmental and resource problems really are, and what should be done about them.

I. **Neo-Malthusians:** (called "gloom-and-doom pessimists" by their opponents) believe that if present trends continue, the world will become more crowded and more polluted, and many resources will be depleted or degraded. They also believe that this will lead to greater political and economic turmoil and increases the threat of nuclear and conventional wars as the rich get richer and the poor get poorer. Most neo-Malthusians are conservationists.

II. **Cornucopians:** (called "unrealistic technological optimists" by their opponents) and most of them are economists. They believe that if present trends continue, economic growth and technological advances will produce a less crowded, less polluted and more resource-rich world. It will also be a world in which most people will be healthier, will live longer, and will have greater material wealth. The term *cornucopian* comes from *cornucopia*, "the horn of plenty", a symbol of abundance.

?*Explain how Cornucopians differ from the Neo-Malthusians in their view about natural resources and their management.* (Use the space below for your answer)

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？*Elaborate the advantages and drawbacks of the views of Neo-Malthusians and Cornucopians to natural resources.* (Use the space below for your answer)

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Table 1: Pros/cons of Cornucopians versus Neo-Malthusians

| **Cases (Issues)** | **Cornucopians** | **Neo-Malthusians** |
|---|---|---|
| Role of Humans on earth | Conquer nature to promote increasing economic growth | Work with nature to promote kinds of economic growth that sustain the earth's life-support system |
| Seriousness of environmental problems | Exaggerated; can be cured by increased economic growth and technological innovations | Serious now and could become more serious without a shift to sustainable forms of economic growth |
| Population growth & control | Should not be controlled; people are our most vital source for solving the world's problem.<br>People should be free to have as many children as they want. | Should be controlled to prevent disruption of local, regional and global life-support system. People should be free to have as many children as they want only if this freedom does not infringe on the rights of others to survive. |

| Cases (Issues) | Cornucopians | Neo-Malthusians |
|---|---|---|
| Resource Depletion and Degradation | We will not run out of potentially renewable resources because of better management or a switch to substitutes. We will not run out of nonrenewable resources because we can find more, mine less concentrated deposits, or find substitutes. Increase in economic growth and technological innovation can reduce resource depletion, pollution, and environmental degradation to acceptable levels. | In many areas potentially renewable resources have already been seriously degraded. There are no substitutes for the earth's topsoil, grasslands, forests, etc. that keep us alive and support many of our economic activities. Substitutes for some nonrenewable resources may not be found or may take too long to phase in without causing economic hardship. Because of high rates of resource use and unnecessary waste, MDCs are causing unacceptable regional and global resource depletion, pollution, and environmental degradation. |
| Energy Resources | Emphasize use of nuclear power and nonrenewable oil, coal, and natural gas | Emphasize use of energy conservation, perpetual solar, wind, and flowing water, and sustainable use of potentially renewable biomass. |

| Cases (Issues) | Cornucopians | Neo-Malthusians |
|---|---|---|
| Resource conservation | Reducing unnecessary resource waste, recycling and reuse are desirable but not if this decreases economic growth for the present generation.<br>We can find a substitute for any scarce resource, so resource conservation is not necessary unless it promotes economic growth. | Reducing unnecessary resource waste is vital for sustaining the earth's life-support systems and long-term economic productivity. It stretches supplies of nonrenewable and potentially renewable resources, and reduces the environmental impact of resource extraction and use. Substitutes may not be found or may be inferior or too costly. |
| wildlife | The earth's wild plant and animal species are here to serve our needs. | Premature extinction of any wild species by human activities is wrong. These potentially renewable resources should be used only on a sustainable basis to meet vital needs, not frivolous wants. |

| Cases (Issues) | Cornucopians | Neo-Malthusians |
|---|---|---|
| Pollution control | Pollution control should not be increased at the expense of short-term economic growth, which can provide funds for pollution control.<br>Polluters should be given government subsidies and tax breaks to install pollution-control equipment.<br>Emphasize output control to reduce pollution once it has entered the environment. Burn, dump, or bury waste materials. | Inadequate pollution control damages people and other forms of life and reduces long-term economic productivity.<br>Polluters should pay for reducing pollution to acceptable levels. Goods and services should include the costs of pollution control so that consumers will know the effects of what they buy and use. Using the "tax-payer pays" approach hides the harmful costs of using goods and services. Emphasize input control to prevent pollution from entering the environment. Think of waste materials as resources that should be recycled, reused, or converted to useful forms. |

**Summary**

Natural resources are resources that are derived from the earth and /or biosphere or atmosphere or hydrosphere and exist independently of human activity. Natural resources can be further classified in to different categories based on different parameters. Some natural resources are available everywhere while others are restricted in some areas of the world only.

Resources in which their amount diminishes as used by human beings are called exhaustible while those resources that are essentially continues in time and cannot be significantly altered by human being are categorized under inexhaustible ones. Resource depletion is a cumulative effect of unwise exploitation and lack of proper management. Different types of approaches can be applied in order to manage and conserve natural resources like integrated natural resource management in which conservation activities are integrated with the livelihood of the community; community based natural resource management that gives more room for the active involvement of the local community in natural resource management process.

Cornucopians differ from the Neo-Malthusians in their stand regarding natural resource management and conservation. Cornucopians stress on output control in controlling pollution while Neo-Malthusian focuses on input control. Seriousness of environmental problems is highly exaggerated for the Cornucopians while it is considered as a critical issue of the 21$^{st}$ century for the Neo-Malthusian. Cornucopians relay on advancement of science and technologies while the Neo-Malthusian on sustainable utilization of natural resources.

**Check list**

Dear learner, now this chapter is over. Put ( ✓) mark in the box against each of the following points if you are sure of it and (×) mark if you are not sure of it. If you put (✓) mark for each case, do the activity followed by the check list and proceed to the next chapter. If there is any (× ) mark, please return back to that issue before proceeding to the next part of the course.

| I can: | | |
|---|---|---|
| 1 | Define the concept of "natural Resources" | ☐ |
| 2 | Differentiate renewable resources from non-renewable ones | ☐ |
| 3 | Explain the essence of integrated natural resource management | ☐ |
| 4 | Elaborate the significance of community based natural resource management | ☐ |
| 5 | Explain the ideas of Cornucopians and Neo-Malthusians regarding natural resource conservation | ☐ |
| 6 | Compare and comment the ideas of Cornucopians and Neo-Malthusians on Natural resource conservation | ☐ |

**Exercise 1:**

1. Explain the advantages of Integrated Natural Resource Management and Community Based Natural Resources Management system.
2. Elaborate the main differences between renewable and non-renewable natural resources.
3. Is there a possibility to renewable resources to become non-renewable and the vice versa? Why/How?
4. Discuss the difference between relative rarity and absolute rarity in natural resource.
5. What is environmental degradation? How could it happen?
6. Of the Neo-Malthusians and Cornucopians view, which one do you believe is better in the case of Ethiopia? Discuss how?

# CHAPTER TWO

# 2. SOIL RESOURCES

**Contents:**



**Objectives:**

✧ **At the end of this chapter, learners will be able to:**

- Identify the basic components of a soil
- Discuss the major soil forming factors
- Identify the major soil forming regimes and explain their difference
- Identify the basic characteristics of major soil profiles
- Explain the basic physical and chemical characteristics of soils
- Discuss the impacts of different biophysical and socio-economic factors which are responsible for soil degradation
- Elaborate the major soil conservation mechanisms

## 2.1 Definition and Components of Soil

Soil is the superficial layer that covers large areas of the earth's crust that has been modified by the natural actions of agents. Soil, which is composed of mineral particles, organic material, water and air, is a valuable natural resource up on which humans depend for. Soil is defined as the upper weathered surface of the earth's crust that is capable of supporting plant life. It is a thin layer of the earth's crust which serves as a natural medium for the growth of plants. Soil development begins with the physical and chemical disintegration of the rock (refers weathering) exposed to the atmosphere and to the action of water percolating down from the surface. The basic result of weathering is the weakening and breakdown of solid rock, the fragmentation of coherent rock masses, the making of little rocks from big ones. The study of soil is called *Pedology*.

The components of soil exist in three states, namely:

- **Solid** - consists of both inorganic (weathered rock materials- minerals) and organic (dead plant and animal materials - humus) substances. The mineral portion which comes from weathered rocks forms the basic soil material. The litter, droppings, remains of plants and animals as well as microorganisms constitutes the organic portion of soils.
- **Liquid** – present in the soil is a complex solution capable of engaging in a multitude of important chemical reactions.
- **Gas** – present in the open pores of the soil.

A good quality of soil consists 45 percent of mineral matter, 25 percent of air, 25 percent of water and 5 percent of organic matter (ideal).

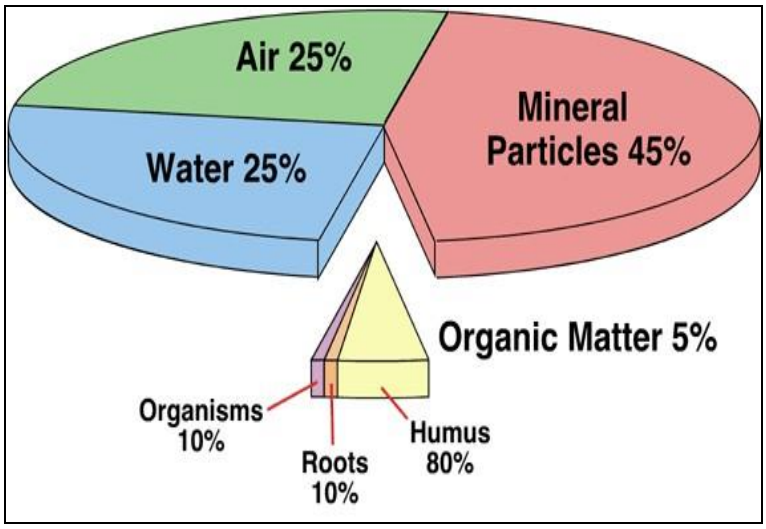


Figure 1: Basic components of a soil

### 2.1.1 Soil Formation Process

#### *2.1.1.1 Weathering- The initial soil forming process*

Soil forming processes form soil after rocks are weathered and after organic materials are decomposed. As it plays the greater role, weathering of rocks will be given due attention here. Mineral soils have originated from the unconsolidated materials (the regolith) that cover the rock. The regolith is first formed from rocks in the processes of disintegration and decomposition, i.e. *weathering*. Weathering is basically a combination of destruction and syntheses. In the beginning, weathering creates the parent materials over which soil formation takes place. Later, weathering, soil formation and development proceed simultaneously.

In weathering, rocks are broken down into small pieces, which are later on further disintegrated into individual rock minerals. The minerals are attacked by bio-chemical reactions to produce new minerals. The new minerals are formed by modification (alteration) in their physical features or by complete chemical changes. The synthesized minerals can be *silicate clays* or the most resistant *iron and aluminium oxides.*

The weathering may be **physical** and **chemical**. The two major processes, i.e. physical and chemical, are involved in the changes mentioned earlier. The processes are involved in the changes (weathering) of parent materials. The physical processes are often considered as **disintegration** while the chemical processes are considered as **decomposition**. Disintegration results in a decrease in size of rocks and minerals without appreciably affecting their composition. By decomposition definite chemical changes take place, soluble materials are released, and new minerals are synthesized or are left as resistant end products.

## 1. Physical Weathering

Disintegration of the rock or of the mineral constituents of a soil under the physical action without any chemical change or formation of new products is referred as physical weathering.
The principal agents of physical weathering are given below.

i. **Temperature**: Warming (day) and cooling (night) is effective in disintegrating rocks. Cracks are created because of variation in the coefficient of expansion of the minerals in the rocks. The surface of rocks peels away because of the lateral differences in temperature. The phenomenon is called *Exfoliation.* High temperatures accelerate the process of chemical weathering, especially in warm humid regions.

ii. **Water**: Torrential rains and flowing waters dislocate the solid particles on the rocks and expose the inner portion to the agents of weathering. The dislodged particles are carried down and deposited elsewhere as alluvium.

iii. **Wind**: Wind exerts an abrasive action, detaches the particles from the rocks and acts as a carrying agent i.e., has both erosive and transportive action. It can cause rounded rock materials in arid areas as a result of the abrasion.

## 2. Chemical Weathering

The chemical decomposition of rock or of the mineral constituents of a soil with a change in chemical composition or formation of new products is referred as chemical weathering. The chemical weathering or decomposition is brought about by the following prominent processes, namely hydrolysis, hydration, carbonation, oxidation, and solution.

i. **Hydrolysis**: In hydrolysis reactions, water molecules split into their hydrogen and hydroxyl components and the hydrogen often replaces a cation from the mineral structure.

ii. **Hydration**: Intact water molecules may bind to a mineral by the process called hydration. In soils, oxides of iron and aluminum are the main compounds undergoing hydration.

iii. **Carbonation**: One of the acids that increase the solvent action of water considerably is carbonic acid. The carbonic acid containing water dissolves almost all carbonates readily.

iv. **Oxidation and Reduction**. Oxidation reduction reactions are characterized by a transfer of electrons, oxidation corresponding to a loss and reduction to a gain of electrons. These reactions can speed up mineral break down by making some minerals more soluble.

v. **Solution**. The solvent action of water is an important means of weathering rocks containing soluble salts, e.g. gypsum and limestone. The solvent action is increased in the presence of carbon dioxide and organic acids realized during the decomposition of organic matter.

? *Dear learners; explain how physical weathering differs from chemical weathering.* (Use the space below for your answer)

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### 3. Biological Weathering

? *Dear learners; explain the role of plants in the weathering process of rocks*. (Use the space below for your answer)

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Biological weathering involves the disintegration of rock and mineral due to the chemical and/or physical agents of an organism. The types of organisms that can cause weathering range from bacteria to plants to animals. Biological weathering involves processes that can be either chemical or physical in character. Some of the more important processes are:

**i.** Simple breaking of particles, by the consumption of soils particles by animals and roots of plants. Particles can also fracture because of animal burrowing or by the pressure put forth by growing roots.

**ii.** Movement and mixing of materials. Many large soil organisms cause the movement of soil particle. This movement can introduce the materials to different weathering processes found at distinct locations in the soil profile.

**iii.** Simple chemical processes like solution can be enhanced by the carbon dioxide produced by respiration. Carbon dioxide mixing with water forms carbonic acid.

**iv.** The complex chemical effects that occur as a result of chelation. Chelation is a biological process where organisms produce organic substances, known as chelates that have the ability to decompose minerals and rocks by the removal of metallic cations.

**v.** Organisms can influence the moisture regime in soils and therefore enhance weathering. Shade from aerial leaves and stems, the presence of roots masses, and humus all act to increase the availability of water in the soil profile. Water is a necessary component in several physical and chemical weathering processes.

**vi.** Organisms can influence the pH of the soil solution. Respiration from plant roots releases carbon dioxide. If the carbon dioxide mixes with water carbonic acid is formed which lowers soil pH. Cation exchange reactions by which plants absorb nutrients from the soil can also cause pH changes. The absorption processes often involves the exchange of basic cations for hydrogen ions. Generally, the higher the concentration of hydrogen ions the more acidic a soil becomes.

### *2.1.1.2 Pedogenic processes*

After the parent material has been deposited, differentiation of layers takes place because of the soil forming (pedogenic) processes that act upon the regolith. The subdivisions of the layers are called **horizons**. The soil forming processes responsible for horizon differentiation are:

a) **Additions to the soil**: Good example is addition of organic matter that creates black layer at the soil surface; mineral matter may also be added.

b) **Losses from the soil**: This may be explained by losses of salts from the soil by drainage. It also includes losses by surface erosion.

c) **Transfer (translocation) with in the soil*:*** e.g. movement of clay particles, organic matter, ions, etc. from A to B-horizon. It can also be movement of materials from subsoil upwards.

d) **Transformations with in the soil**: Mineral and organic matters change their form and composition. The changes can be physical alteration or chemical modification usually resulting in new products or minerals.

These four processes are commonly referred to as Pedogenic processes but sometimes, with more justification, they are referred to as processes of soil change. The processes are believed, by most, as the processes form soil from not-soil. Although this happens, more commonly the processes operate to change the existing soils. This is why referring to them as processes of soil change is more justifiable than calling them processes of soil formation.

## 2.2 Soil Forming Factors

Soil is formed from rock (called parent rock) that is slowly broken down in to smaller and smaller particles by chemical and physical weathering process in nature. Soil formation is a continuous process that involves interaction between the earth's solid crust and the biosphere. The process of soil formation and the properties of the soil are affected and determined by five basic factors namely parent material, climate, time, topography and living organisms. Biology and climate are considered as active factors while that of geology, topography and time as passive factors.

？*Dear learners; what is the impact of parent material in the processes of soil formation?* (Use the space below for your answer)

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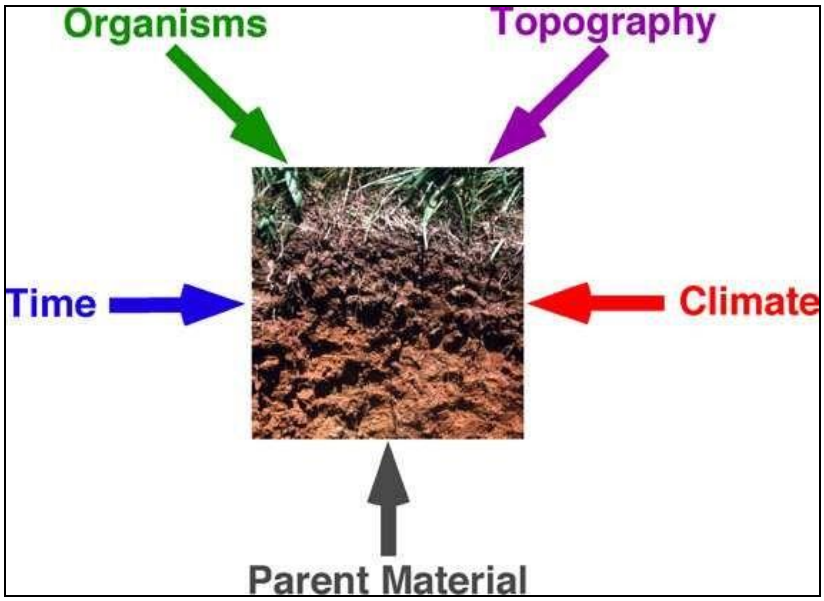


Figure 2: Main factors which affect development of a soil

- **Parent material (geological factor)**– parent material is the mineral matter on which soil is formed. Soils inherit dozens of different minerals from their parent materials that have a wide variety of chemical compositions and a wide range of weathering rates. The parent material from which a soil has evolved may either be underlying bedrock or a layer of unconsolidating deposits. Soils formed on bedrock are termed as **residual soils**, while those developed on unconsolidating deposits are called **transported soils**.

The nature of the parent material influences soils in two ways:-

- The type of parent material (geological factor) affects the rate of weathering and thus the rate of soil formation. Weathering refers to the physical and chemical disintegration and decomposing of rocks. The weathering of parent rock is the prerequisite condition for the formation of soils.

- The chemical makeup of the parent material will affect the fertility of the soil. The features of parent material determine the texture, porosity, drainage, mineral composition, and stratification of the soil.

? *Dear learners; how climatic situation determines the process of soil formation?* (Use the space below for your answer)

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- **Climate: –** the climatic factor refers to the effects of temperature and precipitation on soil formation. Temperature affects the length of the growing season, the speed of vegetation decay and the rate of evaporation. Climate is considered to be the most important control of soil formation. It determines whether chemical or mechanical weathering will predominant and also greatly influences the rate and depth of weathering. For instance, a hot and wet climate may produce a thick layer of chemically weathered soil than a cold and less humid climate. The optimum environment for chemical weathering is a combination of warm temperatures and abundant moisture. The amount of precipitation influences the degree to which various materials are leached from the soil, thereby affecting soil fertility; influences the type of vegetation that grows in an area and thus the supply of humus. Climatic conditions are important controls on the type of plant and animal life present which in turn affect soil formation process. Temperature largely affects the rate of chemical, physical and biological reactions within the soil profile.

- **Time (chronological factor)** - it indicates the length of time that the other factors have been interacting to create a particular soil. The longer the ground surface persists, the more chance there is for ultimate soil development. This explains why most, older soils have well developed horizons due to climatic and biological factors than younger ones.

?*Discuss the impacts of topography on the soil formation process*. (Use the space below for your answer)

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- **Topography** - topography determines the nature of drainage and erosion, which in turn affect the soil forming processes and properties of the soils. The slope gradient, length and aspect affect the physical, biological and chemical properties of soils. Slope has a significant impact on the amount of erosion and the water content of soil. Example;

- Steep slope - slight water soaking (low moisture content); high erosion ( thin soil)
- Waterlogged - poorly drained; aeration problem; thick and very dark
- Flat to undulating - optimum slope

Slope in the mid latitudes affects amount of sunlight energy that affects the process of weathering, type of vegetation and characteristics of soil.

- **Living organisms (Biological factors): -**A mass of mineral particles alone do not constitute a true soil. True soils are influenced, modified, and supplemented by living organisms. Plants and animals aid in the development of a soil through the addition of organic matter. Fungi and bacteria decompose this organic matter into a semi-soluble chemical substance known as humus. Larger soil organisms, like earthworms, beetles, and termites, vertically redistribute this humus within the mineral matter found beneath the surface of a soil. Humus is the biochemical substance that makes the upper layers of the soil become dark. It is colored dark brown to black. Humus is difficult to see in isolation because it binds with larger mineral and organic particles.

Humus provides soil with a number of very important benefits:

- It enhances a soil's ability to hold and store moisture.
- It reduces the eluviation of soluble nutrients from the soil profile.

- It is the primary source of carbon and nitrogen required by plants for their nutrition.
- It improves soil structure which is necessary for plant growth.

Biological factors in short include vegetation, animals and microorganisms which add organic matter to the soil and interact in the nutrient cycle.Various characteristics of plants influence and modify the nature of soils; roots of plants penetrate in the soils so that accelerates weathering process, modify the soil properties because this provides new routes for air, water and organisms in to the soil.The macro and meso-fauna like earth worms, mites, springtails, termites affect and modify the soil properties through burrowing, transporting, mixing of organic and inorganic materials, decompose the organic matter that produce humus.
Burrows and holes also aid the passage of water and air through the soil.

## 2.3 Major Pedogenic Regimes

？*Dear learners; what does soil forming regime mean?* (Use the space below for your answer)

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Soil-forming factors and processes interact in almost limitless variations to produce soils of all descriptions. Fundamental to an understanding of soil classification and distribution is the realization that only five major pedogenic (that is, soil forming) regimes exist: laterization, podozolization, gleization, Calcification and salinization. The regimes are distinguished primarily on the basis of climate as reflected in temperature and moisture availability and secondly on the basis of vegetation cover. In regions where there is normally a surplus of moisture (which is to say annual precipitation exceeds annual evapotranspiration) water movement in the soil is predominantly downward and leaching is a prominent process. In such areas where temperatures are relatively high throughout the year, laterization is the dominant regime; where winters are

long and cold, podozolization predominates; and where the soil is saturated most of the time due to poor drainage, gleization is notable. In regions having a moisture deficit, the principal soil moisture movement is upward (through capillary) and leaching is limited so Calcification and salinization are the principal pedogenic regimes under these conditions.

- **Laterization**: - is named for the brick-red color of the soil it produces (*later*: Latin "brick"). The processes associated with this regime are typical of the warm, moist regions of the world, and significant annual moisture surplus is a requisite condition. The soil formed by laterization is most prominent, then, in the tropics and subtropics, in regions dominated by forest, shrub, and savanna vegetation. A laterization regime is characterized by rapid weathering of parent material, dissolution of nearly all minerals, and speedy decomposition of organic matter. Probably the most distinctive feature of laterization is the leaching away of silica, the most common constituent of most soil and a constituent that is usually highly resistant to being dissolved. Most other minerals are also leached out rapidly, leaving behind primarily iron and aluminum oxides and barren grains of quartz sand. This residue normally imparts to the resulting soil the reddish color that gives this regime its name. The A horizon is highly eluviated and leached, whereas the B horizon has a considerable concentration of illuviated materials.

? *Dear learners; inwhat type of climatic situation does podozolization takes places?* (Use the space below for your answer)

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- **Podozolization**: - is another regime named after the color of the soil it produces; in this case gray (*podozol*: Russian for "like ashes"). Podozolization occurs primarily in areas where the vegetation has limited nutrient requirements where the plant litter is acidic. These conditions

are most prominent in mid and high-latitude locales having a coniferous forest cover. The typical location for podozolization is under a boreal forest in subarctic climates, which is found only in the Northern Hemisphere.

- **Gleization**: - is a regime restricted to waterlogged areas, normally in a cool climate. (The name comes from *glej,* Polish for "muddy ground"). The poor drainage that produces a waterlogged environment can be associated with flat land, but it can also result from a topographic depression, a high water table, or various other conditions.

- **Calcification:** - in arid and semiarid climates, where precipitation is less than potential evapotranspiration, leaching is either absent or transitory. Natural vegetation in such areas consists of grasses or shrubs. Calcification (so called because many calcium salts are produced in this regime) is the dominant pedogenic process in these regions, as typified by the drier prairies of North America, the steppes of Eurasia, and the savannas and steppes of subtropics. Both eluviation and leaching are restricted by the absence of percolating water, and so materials that would be carried downward in other regimes become concentrated in the soil where calcification is at work. Moreover there is considerable upward movement of water by capillary action in dry periods. Calcium carbonate ($CaCO_3$) is the most important chemical compound active in a calcification regime. Where calcification takes place under undisturbed grassland, the resulting soils are likely to have remarkable agricultural productivity. Humus from decaying grass yields abundant organic colloidal material and contributing to a structure that can retain both nutrients and soil moisture.

- **Salinization:** - in arid and semiarid regions, it is fairly common to find areas with inadequate drainage, particularly in enclosed valleys and basins. Moisture is drawn upward and into the atmosphere by intense evaporation. The evaporating water leaves behind various salts in or on the surface of the soil, sometimes in such quantity as to impart a brilliant white surface color to the land, the pedogenic regime is called salinization. These salts, which are mostly chlorides and sulfates of calcium and sodium, are toxic to most plants and soil organisms, and the resulting soil is able to support very little life apart from a few salt tolerant grasses and shrubs.

## 2.4 Soil Profile and Physical Properties

**Soil Profile**- soil profile is a vertical cross section through the soil showing different horizons that extends up to the parent material. It is made up of a succession of horizontal layers or horizons, each of which varies in thickness, color, texture, structure, consistency, porosity, acidity and composition.

**Soil Horizons –** are layers in the soil profile characterized by distinctive characteristics of physical and chemical features, organic content, structure, texture, moisture content, porosity, color etc. The soil horizons of soil profile are basically divided in to two broad categories, namely:

- Organic horizons (designated by letter O)
- Mineral horizons (designated by letter A, E, B, C and R)

**Organic horizon**

**O-horizon (**O for organic): - This part is sometimescalled the surface layer or top most layers of the soil profile which contains largely of fresh and decaying organic matter that are derived from dead plants and animals like leaves, twins, animal droppings, dead insects, and so on.

?*Dear learners; what is the difference between $O_1$ and $O_2$ layers?* (Use the space below for your answer)

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It is further subdivided in to two parts as:

- **$O_1$**- the upper most layer of the organic horizon and consists of the original form of vegetative matter as fresh litter or party decomposed litter.
- **$O_2$** – characterized by the altered remains of plants and animals (humus) through decomposition (called humification).

- **Inorganic Horizons (A, E, B ,C and R )**

**A-Horizon: -** is a mineral horizon that also contains considerable organic matter.

- Humus and clay particles are particularly important because they provide essential chemical links between soil nutrients and plants
- Is rich in organic content and hence darker than lower horizons
- Seeds germinate mostly in this horizon
- The part of the soil where biological activity and humus content are at their maximum.
- Is most affected by the leaching of soluble materials and by the down ward movement (eluviation) of clay particles by percolating water. Eluviation is the washing out or removal of organic and mineral matter from the A-horizon. If leaching of dissolved materials from A-horizon is very extensive, the soil takes on a grey color; lime will also be carried down wards in solution, and the soil becomes rather acid.

**E- Horizon: -** it is normally lighter in color than either the overlying A or the underlying B horizon. It is essentially an eluvial layer from which clay, iron and aluminum have been removed, leaving a concentration of abrasion-resistant sand and silt particles. The process by which gravitational water picks up fine particles of soil from the upper layers and carries them downwards to the lower horizons called eluviation (out washing).

**B- Horizon: -** usually is called subsoil, is a mineral horizon of illuviation (a deposition process or in washing) where most of the materials removed from above have been deposited. A collecting zone for clay, iron and aluminum, this horizon is usually of heavier texture, greater density and relatively greater clay content than the A-horizon. The layer exhibit reddish and yellowish color because of the illuviated presence of minerals and organic oxides.

**C- Horizon -** is unconsolidated parent weathered parent material beyond the reach of plant roots and most soil forming processes except weathering. It is the part where weathering is slowly transforming bed rock in to soil particles.

**R- Horizon (bedrock):-** R horizons basically denote the layer of partially-weathered bedrock at the base of the soil profile. Unlike the above layers, R horizons largely comprise continuous masses (as opposed to boulders) of hard rock that cannot be excavated by hand. It is the unaltered bedrock (R for regolith).

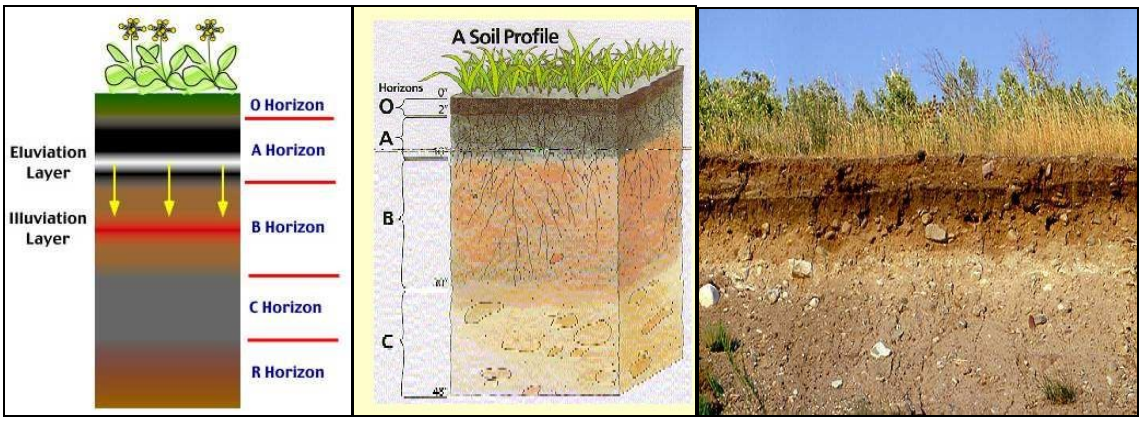


Figure 3: Major Soil Horizons

The soil profile is characterized by the following common properties:

- There is a gradual decrease of organic matter, number of living organisms, activity of living organisms etc. with increasing depth.
- The level of aeration of soil decreases from the surface downwards
- There is increase in the number and variety of parent materials from the surface downwards in the soil profile up to the base
- There is no definite trend of either increase or decrease in the content of soil water with depth because there is a lot fluctuation in water content.

**Soil properties**

Soil properties are the characteristics that enable us to distinguish one type of soil from another.

**Soil Color: -** Soil color may be inherited from the parent material (that is litho-chromic) or it may be due to soil forming processes (acquired or genetic color). Dark color soils are generally higher in organic matter than light ones. Red and yellow colored soils are the result of iron oxide, bright color indicate good drainage and good aeration. Soil color influences soil temperature that in turn affects rate of evaporation.

**Soil Texture: -** Soil texture refers to the size of mineral particles that affect the porosity of soils and is determined by the proportion of sand, silt and clay particles. The porosity in turn determines how much moisture the soil can hold, how fast water moves through the soil. The texture of a soil is determined by the amounts of different sized inorganic particles (sand, silt and clay).

- Sand - 0.05 up to 2 mm of diameter (coarse textured soils)
- Silt 0.002 - 0.05mm diameter
- Clay - less than 0.002mm diameter (fine textured soils)
- Loam - good (ideal agricultural soil) has approximately equal proportions of sand, silt & clay.

Soil texture affects the movement and availability of water, aeration, workability, the content of plant nutrients. Sandy soils (coarse grained) are very permeable and well drained but are less water retentive while clayey soils can hold more moisture and the rate of water intake is low that

leads to water logging resulting in poor aeration and workability. The most agriculturally productive soil, called loam soil, is about 40% sand, 40% silt and 20% clay.

？*What does soil porosity mean? How it affects free movement of water and air*? (Use the space below for your answer)

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**Soil Porosity: -** The space presented between soil particles in a given volume of soils are called pore spaces and the percentage of soil volume occupied by pore space is called porosity. Porosity of soils depends upon the texture, structure compactness and organic contents of the soil.

Table 2: Relation between soil properties and soil texture

| Soil property | Soil texture type | | |
|---|---|---|---|
| | Sand | Silt | Clay |
| Aeration | Excellent | Good | Poor |
| Drainage | Excellent | Good | Poor |
| Nutrient holding capacity | Low | Medium | High |
| Water holding capacity | Low | Medium | High |
| Workability(tillage) | Easy | Medium | Difficult |

**Soil pH: -** Soil pH is the degree of acidity or alkalinity of the soil and it is primarily controlled by the concentration of free hydrogen ions in the soil matrix. Soils with a relatively large concentration of hydrogen ions tend to be acidic. Alkaline soils have a relatively low concentration of hydrogen ions. Hydrogen ions are made available to the soil matrix by the dissociation of water, by the activity of plants roots, and by many chemical weathering reactions.

A solution with a pH of less than 7 is acidic; one with a ph of 7 is neutral; and one with a pH greater than 7 is basic or alkaline. Soil pH is important characteristics of soil that influences plant growth. In areas with much rain, soils will usually be acidic while in semiarid areas, since rainfall amount is low, calcium and other alkaline compounds are not leached away so that soils are mostly alkaline. Acidic soils can be corrected by adding and mixing ground limestone to the soil.

## 2.5Soil Degradation and Factors

？*Dear learners; define the concept "soil degradation".* (Use the space below for your answer)

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？*What major biophysical and socioeconomic factors are common in your locality? Which are responsible for soil degradation?* (Use the space below for your answer)

Soil erosion is the removal of soil from its original position or place by different agents like water (running water, melting ice, wave or tide etc.) wind and gravity. Erosion in all its forms involves the dislodgement of soil particles, their removal and eventual deposition away from the original position. The rate at which soil erosion occurs depends on the vegetation cover of the land surface, the slope, the size of rock fragments and soil particles at the surface, and climatic condition. Soil degradation, which is the decline of soil fertility caused mostly through its misuse by human activity, incorporates a number of environmental problems like acidification, aridification, biological degradation, compaction, crusting (sealing), eutrophication, nutrient depletion, pan formation, pollution, Salinization, subsidence, terrain deformation, water logging and erosion.

- **Acidification**: it implies a lowering of soil pH by mobilizing or increasing acidic compounds in the soil. The problem of acidification may be caused by over application of acidifying fertilizers, planting of acidifying vegetation, or draining soils containing pyrite (creating acid sulphate soils). It mostly occurs in humid and sub humid climates through nutrient leaching of naturally acid soils having low organic matter.

- **Aridification**: it refers to the decreasing of the average soil moisture content. Possible causes are the lowering of ground water tables for agriculture purpose or drinking water extraction, or decreased soil cover and reduced organic matter.

- **Biological Degradation**: it includes a decline in carbon bio-mass, reduction in organic matter content, and decrease in flora and fauna populations resident in the soil. It is in most

cases caused by intensive row cropping, mechanical soil disturbance, accelerated soil erosion, excessive application of pesticides, or waste contamination.

- **Compaction**: results from deterioration of soil structure by trampling of cattle or the weight and/ or frequent use of heavy machinery. Soils with low organic matter, poorly sorted sand fractions, and appreciable amounts of silt are more prone to compaction and sealing.

- **Crusting (sealing):** crusting refers to the clogging of soil pores with fine soil materials and the development of a thin impervious layer at the soil surface that obstructs the infiltration of water. Possible causes include poor soil cover, allowing maximum "splash" effect of raindrops; the destruction of soil structure; and low organic matter.

- **Eutrophication**: is refers to an excess of certain soil nutrients which may be caused by imbalanced application of organic and chemical fertilizer, resulting in excess nitrogen or phosphorous and impairing plant growth.

- **Nutrient Depletion**: it indicates a net decrease of available nutrients and organic matter in the soil mainly caused by a negative balance between output (harvesting, burning, leaching and so on) and input of nutrients and organic matter (manure/fertilizers, crop residues, flooding) of nutrients and organic matter.

- **Pan Formation:** is naturally occurring physical changes in soil structure that result in formation of a layer impermeable to roots or the flow of water.

Pollution: is soil degradation as a result of the concentration and adverse biological or toxic effects of a substance either from local sources like waste dumps, spills and factory sites or diffuse or air born pollution.

Salinization: is an increase of the soluble salt content like sodium chloride or sodium sulphate of the soil due to intrusion of sea water, improper irrigation practice, or evaporation of saline groundwater.

- **Terrain Deformation**: is an irregular displacement of soil material causing clearly visible scars in the terrain which is probably caused by water erosion (like gulley or rill erosion) or mass movement of the land.

- **Water Logging**: The causes are a rising water table due to construction of reservoirs or irrigation or increases flooding caused by higher peak flows of rives.

- **Erosion**: is the actual physical movement of soil particles from one location to another by agents of water and wind.

Soil Erosion is a cumulative effect of biophysical and socioeconomic factors.

- **Biophysical Factors:** Biophysical factors include rainfall, topography, soil type, vegetation cover, etc. High rainfall intensity and erosive storms make soils vulnerable to erosion. The topography has also much to aggravate erosion; thus steep slopes are much vulnerable than gentle ones. Different soils have varied degree of erodibility. Soils with very less organic matter are easily vulnerable to different agents of soil erosion. Lack of Vegetation cover also aggravates removal of soils.

- **Socioeconomic Factors**

The most prominent socioeconomic factors that accelerate the rate of soil erosion include deforestation, over cultivation of crop lands, overgrazing and traditional farming practices aggravates soil erosion.

## 2.6Management and Conservation of Soils

? *Dear learners; what kind of soil conservation mechanisms are practiced in your locality?* (Use the space below for your answer)

Soil conservation is a part of conservation of the land: the protection, improvement and use of the natural resources according to principles that will assure their highest benefit. The prime objective of soil conservation is to provide for the permanent maintenance of the soil's productive potential.

Three criteria to select the type of soil conservation techniques:

- ***Efficiency*** - does the approach conserve soil and maintain fertility?
- ***Acceptance*** - its capability of being integrated into farming systems, and is it acceptable socio- politically, culturally and technologically?
- ***Cost*** - is the method cost effective? Are extra resources needed?

Success in soil conservation involved from a combination of different factors like:

- Land users need to be involved from the start in planning conservation schemes
- Farmers will only adapt and continue conservation methods if they can see some direct benefit
- Land tenure system (assured long term right or control)
- Appropriateness and practicability conservation practice to local conditions

### 2.6.1Major Soil Conservation Technique

Some of the soil conservation techniques include (both agronomic and Physical/mechanical methods):

- **Mulching:** - means covering the soil with straw, cut weeds, leaves, stems etc. It helps to protect the soil from the impact of splash; reduces evaporation (increases the moisture holding capacity of the soil), temperatures regulation and freezing & thawing of the soil. It also reduces the velocity of run off and wind.

- **Contouring (contour furrows):** - placing plant rows and tillage lines at right angles to the normal flow of surface runoff. It slows down the runoff and gives the water more time to infiltrate in to the soil instead of directly rushing off.

- **Contour line ditch (grass strip**): - if the slope is very steep and if the water flows very fast, ridge can be carried away. Grasses instead of crops are grown on the ridge so that the roots prevent the water from carrying away the ridge.

- **Terracing: -**Terracing is the mechanical practice used on slopping agricultural land to reduce the length and /or the degree of slope. The major types of terraces include:

1. **Level terrace or contour Bunding:** It involves construction of bund passing through the points having same elevation (contour). The bund may have closed or open ends. the main objectives is to impound the surface run-off and hold it until it infiltrates, closed end bunds are built in low rainfall areas with high permeability and open end bund is used for soil with moderate permeability. Whatever be the case, contour bunding is not suitable for slopes steeper than 6%.
2. **Channel Terrace or Graded Bunding**: In heavy rainfall areas, the water cannot be impounded to percolate into soil. As such slight gradient is provided in channel above the bund to safely divert water to one side of field. Then the water is discharged safely from grassed waterway. There are following types:
3. **Bench terraces:** A steep slope is converted into a series of steps, with horizontally or nearly horizontal ledges, and vertical or almost vertical walls between the ledges. In very stable soils, the walls may be held by vegetation, and in others some structural walls are necessary, as brick, stone or timbe

- **Strip cropping or barrier strips**: -is the farming of sloping land in alternate strips of interfilled row of crops and enclosed growing crops. The strips of closed-growing crops slow water runoff. Reduce soil erosion, decrease damage from pests and plant diseases; helps to restore soil fertility especially when legumes are used.

- **Inter cropping**: - In this method, the spaces among the tree species are covered with agriculture crops, which help in soil and water conservation. When crops are grown between the rows of other growing crops, the ground is not exposed to erosion.
- **Artificial water way**: - a drainage channel used to safely divert runoff from cultivated fields.

- **Crop rotation**: - planting of a series of different crops in the same field over a period of time alternatively, so that the soil fertility is maintained.

- **Mixed cropping**: - In this system two or more than two crops are raised in the same land and in the same time. The benefit is that due to different kind of roots, soil is protected more perfectly.

- **Agro forestry**: - a land use system practiced where woody perennials are deliberately used on the same land management unit as agricultural crops. In agro forestry, both ecological and economic interactions are maintained. The most common agro forestry systems include alley cropping, boundary planting of trees, use of woody perennials in soil conservation, tree gardens etc. Trees can be incorporated within a farming system by planting them on terraces, contour bounds and as ornamental around the homestead. This reduces soil erosion and provides additional needs to the farmers like fuel, fruits, forage etc.

- **Alley cropping**: - cultivation of annual crops between rows of trees or hedgerows (sometimes called hedgerow intercropping)

- **Shifting cultivation**: - an areas forest is cleared by slash and burn, and cultivated with crops for a second year before being allowed to revert to scrub and secondary forest. This practice will maintain soil fertility and reduce soil erosion as long as the low ratio population to land areas is maintained.

- **Reforestation / afforestation**: - vegetation play the major role in erosion control on gullies areas and landslides. So afforestation programs should be prioritized.

- **Wind breaks***:* - Windbreaks are usually used in plain areas where the wind moves rapidly and forcibly which detaches soil particles causing soil erosion. In this method tree species of strong trunk, deep rooted and large crown are preferred which are raised around the agricultural land.

- **Check dams**: The structure constructed to control the velocity of running water along the gullies is called check dams. They reduce the steep gradient of gully into a series of steps with low rises and long flat treads, reducing the velocity of running water. This makes water to deposit and increase the percolation of water on a soil.

- **Area closure**: this is a protection system to improve land with degraded vegetation and/or soil through natural regeneration. In this case no livestock is allowed to graze, and no human interference tolerated for 3-5 years until at least 80% of the natural cover is obtained. The area can be utilized as soon as satisfactory state of recovery has been attained. For example, cut and carry system of grasses is possible after recovery time.

? *Dear learners; is area enclosure used as a natural resource conservation method in your wereda?If so, explain how people in the locality use resources from such area.* (Use the space below for your answer)

**Summary**

Soil, which is composed of mineral particles, organic material, water and air, is a valuable natural resource up on which humans depend for. Soil formation is a continuous process that involves interaction between the earth's solid crust and the biosphere. The process of soil formation and the properties of the soil are affected and determined by five basic factors namely parent material, climate, time, topography and living organisms. A good quality of soil consists 45 percent of mineral matter, 25 percent of air, 25 percent of water and 5 percent of organic matter. Soil-forming factors and processes interact in almost limitless variations to produce soils of all descriptions. The major Pedogenic (that is, soil forming) regimes exist: Laterization, podozolization, gleization, Calcification and Salinization. The regimes are distinguished primarily on the basis of climate as reflected in temperature and moisture availability and secondly on the basis of vegetation cover. Soil erosion is the removal of soil from its original position or place by different agents like water (running water, melting ice, wave or tide etc) wind and gravity. Erosion in all its forms involves the dislodgement of soil particles, their removal and eventual deposition away from the original position.

Soil conservation is a part of conservation of the land: the protection, improvement and use of the natural resources according to principles that will assure their highest benefit. The prime objective of soil conservation is to provide for the permanent maintenance of the soil's productive potential. Different soil conservation and management system can be applied like mulching, terracing, crop rotation, inter-cropping,mixed- cropping, strip cropping or barrier strips, agro forestry, alley cropping, check dams, wind breaks and reforestation / afforestation

**Check list**

Dear learner, now this chapter is over. Put (✓ ) mark in the box against each of the following points if you are sure of it and (✖) mark if you are not sure of it. If you put (✓ ) mark for each case, do the activity followed by the check list and proceed to the next chapter. If there is any (✖ ) mark, please return back to that issue before proceeding to the next part of the course.

I can:

| | | |
|---|---|---|
| 1 | Identify the major components of soil | ☐ |
| 2 | Explain the difference between physical, chemical and biological Weathering processes | ☐ |
| 3 | Explain the impacts of soil forming factors on soil formation process | ☐ |
| 4 | Discuss the characteristics of the major Pedogenic regimes | ☐ |
| 5 | Explain the characteristics of the major layers of a soil | ☐ |
| 6 | Explain the physical and chemical characteristics of a soil | ☐ |
| 7 | Explain the basic forms of soil degradation | ☐ |
| 8 | Discuss the causes and consequences of soil degradation | ☐ |
| 9 | Elaborate the main soil conservation techniques | ☐ |

**Exercise 2:**

1. What is weathering? Differentiate physical weathering, chemical weathering and biological weathering.
2. What is parent material and what is the role of parent material in soil formation?
3. Why do we call the O horizon as organic?
4. Differentiate Aridification from Acidification.
5. Amongst the soil horizons, which one is less likely to be affected by degradation and why?

# CHAPTER THREE

# 3. NATURAL VEGETATION

**Contents:**



**Objectives:**

✧ **At the end of this chapter, learners will be able to:**

- Define Natural Vegetation
- Discuss Classification of Terrestrial Ecosystem
- Describe the Ecological Role of Forests
- Identify the basic characteristics of major soil profiles
- Explain the Causes of Degradation of Natural Vegetation
- Discuss the Consequence of Deforestation
- Elaborate the Conservation and Management of Natural Vegetation

## 3.1 Definition of Natural Vegetation

?*Dear learners; can you define what a natural vegetation is?* (Use the space below for your answer)

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The term natural vegetation is commonly used to describe the natural growth of plants as distinct from the cultivated plant growth, which covers the earth's surface. The areas of unchanged natural vegetation are now limited in extent. The occurrence, nature and type of natural vegetation in any area are influenced by a variety of factors like:

- Climate – moisture, temperature, wind, etc.
- Edaphic – soil condition
- Physiographic like structure, relief, altitude, slope, aspect
- Biotic – influence of organic life
- Anthropogenic - human influence due to clearance, burning, drainage

## 3.2 Classification of Terrestrial Ecosystems

The geographic classification of natural vegetation is as difficult as the classification of any other complex phenomena influenced by a variety of factors. However, plant communities are among the most highly visible of natural phenomena, so they can be categorized on the basis of form and structure or on gross physical characteristics. Of course, the composition of the natural vegetation changes from place to place in a transitional manner, just as temperature and rainfall do, and although distinctly different types are apparent, there may be broad transition zones between them.

Nevertheless, over the world there are distinctive recurring plant communities, indicating a consistent botanical response to systematic controls that are essentially climatic. It is the dominant vegetation of these plant communities that we recognize when we classify Earth's major terrestrial ecosystems (biomes).

Plant communities commonly classified, based on the types, growth stage and composition of the plants, as forest, woodlands, shrub lands, grasslands, desert, wetlands, tundra etc.

1. **Forest**: - A forest is a community of living trees and associated organisms covering a considerable area, utilizing sunshine, air, water and earthy materials to attain maturity and to produce itself, and capable of furnishing humankind with indispensable products and services. A forest is a complex ecosystem which is predominantly composed of trees, shrubs and is usually a closed canopy. Forests are storehouses of a large variety of life forms such as plants, mammals, birds, insects and reptiles etc. Also the forests have abundant microorganisms and fungi, which do the important work of decomposing dead organic matter thereby enriching the soil. Nearly 4 billion hectares of forest cover the earth's surface, roughly 30 percent of its total land area

2. **Woodlands**: - are tree-dominated plant associations in which the trees are spaced more widely apart than in forests and do not have interlacing canopies. Woodland environments generally are drier than forest environments.

3. **Shrub lands**: - are plant associations dominated by relatively short woody plants, generally called shrubs or bushes. Most shrubs have several stems branching near the ground and leafy foliage that begins very close to ground level. Trees and grasses may be interspersed with the shrubs but are less prominent in the landscape. Shrub lands have a wide latitudinal range, but they are generally restricted to semi-arid or arid locales.

4. **Grass lands**: - may contain scattered trees and shrubs, but the landscape is dominated by grasses and forbs (broad leaf herbaceous plants) and mostly associated with semi-arid and

sub humid climate. Prominent types of grass land include Savanna in the low-latitude, Prairie in the mid latitude (tall grass) and Steppe in the mid latitude (short grass).

5. **Deserts**: - are typified by widely scattered plants with much bare ground interspersed. Desert is actually a climate term, and desert areas may have a great variety of vegetation, including grasses, succulent herbs, shrubs and straggly trees.

6. **Wet lands**: - are characterized by shallow standing water all or most of the year with vegetation rising above the water level. The most widely distributed wet lands are swamps (with trees as the dominant plant forms) and marshes (with grasses and other herbaceous plants dominant).

7. **Tundra**: - consists of a complex mix of very low plants including grasses, forbs, dwarf shrubs, mosses and lichens, but no trees.

All of Earth's biomes can be categorized into one of five easily recognized types: forest, savanna, grassland, desert, and tundra.

1. **Forest Biomes**

Forests are easily recognized as associations of large, woody, perennial tree species, generally several times the height of a human, and with a more or less closed canopy of leaves overhead. They vary enormously in density and physical appearance. Some are evergreen and either needle- or broad-leaf; others are deciduous, dropping their leaves to reduce moisture losses during dry seasons or when soil water is frozen. Forests are found only where the annual moisture balance is positive where moisture availability considerably exceeds potential evapotranspiration in the growing season.

Thus, they occur in the tropics, where either the Inter Tropical Convergence Zone (ITCZ) or the monsoonal circulation brings plentiful rainfall, and in the middle latitudes, where precipitation is

associated with cyclones along the polar front, with summer convectional rainfall, or with orographic uplift.

### i. Tropical Forests

The forests of the tropics are far from uniform in appearance and composition. They grade pole ward from the equatorial rainforests, which support Earth's greatest biomass, to the last scattering of low trees that overlook seemingly endless expanses of tall grass or desert shrubs on the tropical margins.

Tropical forests can be subdivided into three distinct biomes: the **tropical rainforest**, the **monsoon rainforest**, and ***tropical scrub***forest types:

**a.** ***Tropical Rainforest***: In the tropical rainforest climate, the only physical limitation for vegetation growth is competition between adjacent species. The competition is for light. Temperatures are high enough to promote constant growth, and water is always sufficient. Thus, we find forests consisting of an amazing number of broad-leaf evergreen tree species of rather similar appearance because special adaptations are not required. The distribution of this biome is closely related to climate-consistent rainfall and relatively high temperature (areas where the average temperature ranges from 21-27$^{O}$C or higher; rainfall from 1800-5000mm per annum and well distributed throughout the year). It contains a bewildering variety of trees growing in close conjunction. Mostly they are tall, high-crowned, broadleaf species that never experience a seasonal leaf fall.

Rainforest fauna is largely arboreal (tree dwelling) because the principal food sources are in the canopy rather than on the ground. The animal life of this biome is characterized by creepers, crawlers, climbers and flyers. Most of the tropical rain forests are found in the Amazon River basin in South America, Central America, and the Congo River basin in Africa, the South East coast of Africa, India, South East Asia, the Philippine Island and North Eastern Australia.

**b.** ***Tropical Deciduous /Monsoon Rainforest****:* In areas of monsoonal circulation, there is an alternation between the dry monsoon season, when the dominant flow of air is from the land to the sea, and the wet monsoon season, when the atmospheric circulation reverses, bringing moist air onshore along tropical coasts. The wet monsoon season rainfall may be very high, even hundreds of centimeters where air is forced upward by topographic barriers. In any case, it is sufficient to produce a forest that, once established, remains despite coming dominant. In tropical deciduous forest the canopy is less dense, the trees are somewhat shorter, and there are fewer layers, all these details being a response to either less total precipitation or less periodic precipitation.

**c.** ***Tropical Scrub or Thorn Forest****:-* the very dry, tropical thorn forests occurs along the dry and coastal areas of Mexico, northern and southern America, Africa, India and the northern portion of Australia. The climate in these regions is uniformly hot, and the dry season extends over most of the year with rainfall of 250-630 mm per year. It is dominated by low-growing, scraggly trees and tall bushes, usually with an extensive under story of grasses. In the more tropical and wetter portions of the tropical scrub biome, most of the trees and shrubs are evergreen; elsewhere most species are deciduous. The forest is the transitional zone between the typical deciduous forest and the typical desert. The trees and shrubs like acacia and mesquite are small deciduous and usually widely scattered.

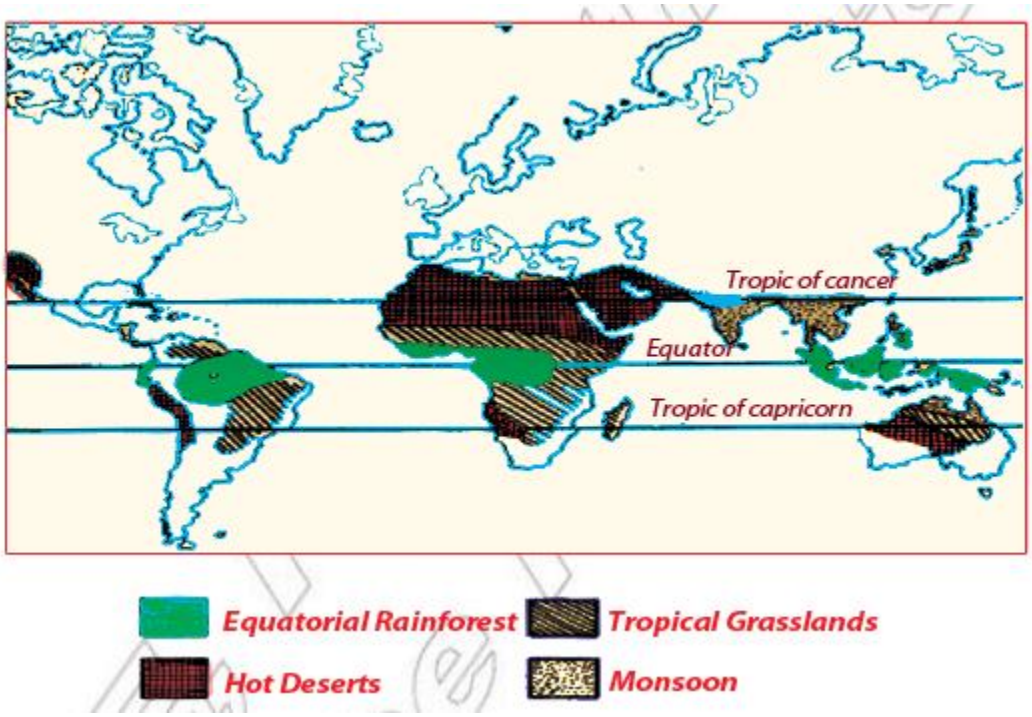


Figure 7: Tropical Forests

### ii. Middle Latitude Forests

The forest biomes of the middle latitudes differ from those of the tropics because the dominant trees have evolved mechanisms to withstand periods of water deprivation due to low temperatures and annual variations in precipitation. Evergreen and deciduous plants are present, equipped to cope with seasonal extremes not encountered in tropical latitudes.

***a.*** ***Mediterranean Sclerophyllous Woodland***: Surrounding the Mediterranean Sea and on the southwest coasts of the continents between approximately 30° and 40°N and S latitude, we have seen that a distinctive climate exists Köppen's mesothermal hot-and dry-summer type (Mediterranean). Here annual temperature variations are moderate, and freezing temperatures are rare. However, little or no rainfall occurs during the warmest months, and plants must be drought resistant. This requirement has resulted in the evolution of distinctive vegetation that is relatively low growing, with small, hard-surfaced leaves and roots that probe deeply for water.

The leaves must be capable of photosynthesis with minimum transpiration of moisture. The general look of the vegetation is a thick scrub plant community, called **chaparral** in the western United States and ***maquis*** in the Mediterranean region.

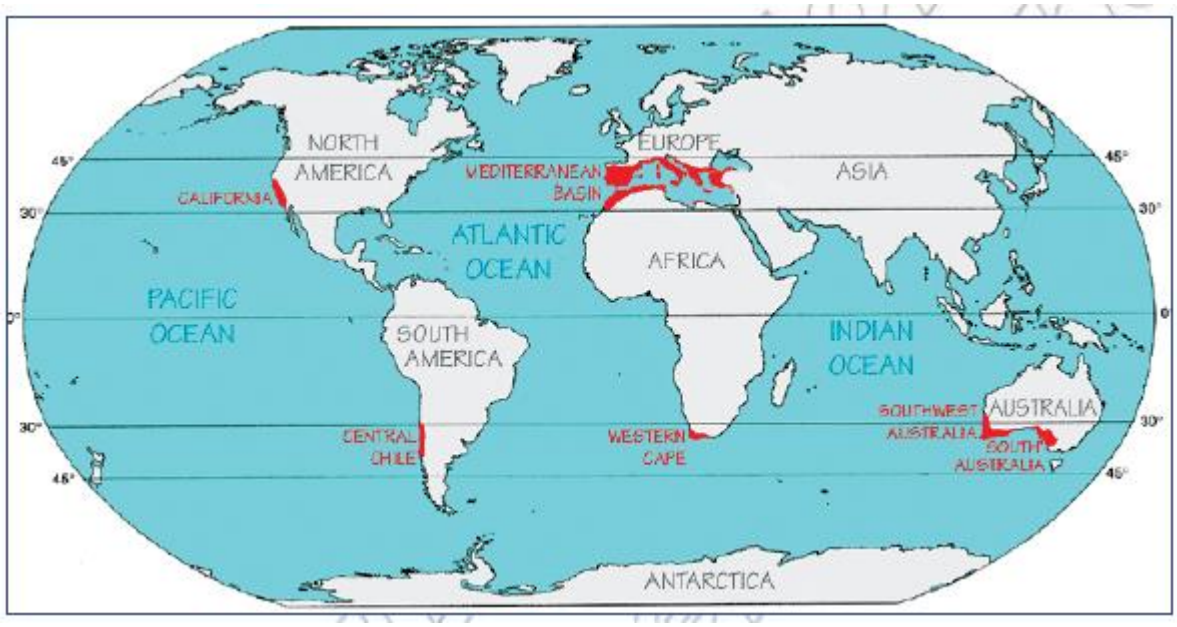


Figure 8: The Mediterranean Region

***b. Broad-Leaf Deciduous Forest****:* The humid regions of the middle latitudes experience a seasonal rhythm dominated by warm tropical air in the summer and invasions of cold polar air in the winter. To avoid frost damage during the colder winters and to survive periods of total moisture deprivation when the ground is frozen, trees whose leaves have large transpiring surfaces drop these leaves and become dormant, coming to life and producing new leaves only when the danger period is past. A large variety of trees have evolved this mechanism; certain oaks, hickory, chestnut, beech, and maples are common examples. The trees of the deciduous forest may be almost as tall as those of the tropical rainforests and, like them, produce a closed canopy of leaves overhead or, in the cold season, an interlaced network of bare branches. However, lacking a multi-storied structure and having lower density as a whole, the middle-latitude deciduous forests allow much more light to reach ground level.

***c.*** ***Mixed Forest*****:** Pole ward and around the equator, the broad-leaf deciduous forests in North America, Europe, and Asia gradually merge into mixed forests, including needle-leaf coniferous trees, normally pines. In general, where conditions permit the growth of broad-leaf deciduous trees, coniferous trees cannot compete successfully with them. Thus, in mixed forests, the conifers, which are actually more adaptable to soil and moisture deficiencies, are found in the less hospitable sites: in sandy areas, on acid soils, or where the soil itself is thin. The northern mixed forests reflect the transition to colder climates with increasing latitude; eventually, conifers become dominant in this direction.

***d.*** ***Coniferous Forest****:* The coniferous forests occupy the frontiers of tree growth. They survive where most of the broad-leaf species cannot endure the climatic severity and impoverished soils. The hard, narrow needles of coniferous species transpire much less moisture than do broad leaves so that needle-leaf species can tolerate conditions of physiologic drought (unavailability of moisture because of excessive soil permeability, a dry season, or frozen soil water) without defoliation. Pines, in particular, also demand little from the soil in the form of soluble plant nutrients, especially basic elements such as calcium, magnesium, sodium, and potassium. Thus, they grow in sandy places and where the soil is acid in character. As a whole, conifers are particularly well adapted to regions having long, severe winters combined with summers warm enough for vigorous plant growth. Such as calcium, magnesium, sodium, and potassium. Thus, they grow in sandy places and where the soil is acid in character. As a whole, conifers are particularly well adapted to regions having long, severe winters combined with summers warm enough for vigorous plant growth.

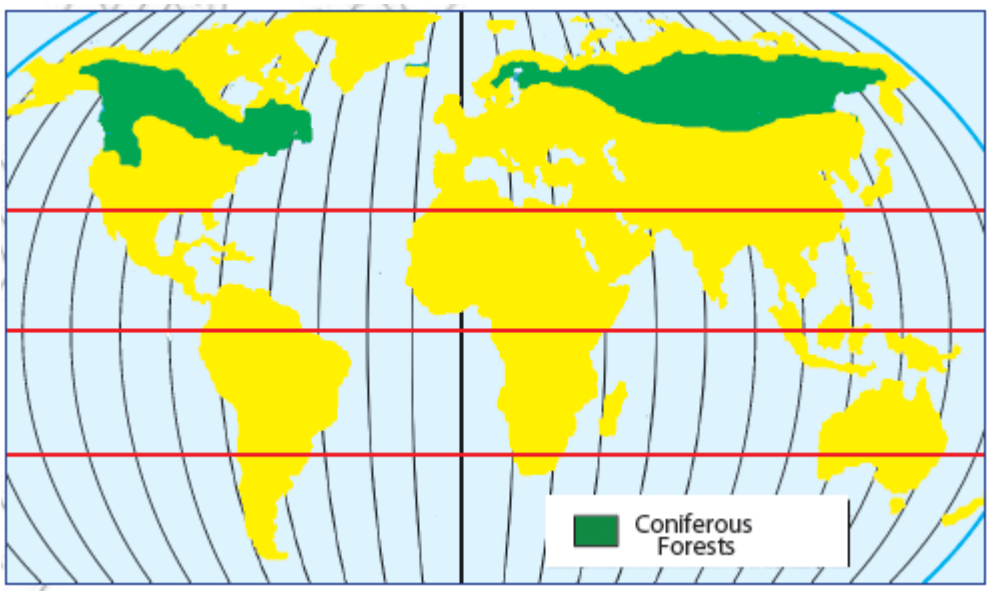


Figure 9: The coniferous Forest

## 2. Savanna Biome

Is the transitional between forests and grass lands and it exhibits an open cover tree with grasses and herbs underneath (extensive grasslands dotted with trees). It is usually associated with the tropical wet-dry climate of Africa, South America, India, and Australia.

Trees are spaced widely apart because soil moisture during the dry season is not sufficient to support a full tree cover. The open spacing permits development of a dense lower layer, which consists of grass. The world's largest and best-known savanna is the African savanna, which covers much of the continent south of the Sahara desert. In the African savanna, herds of animals graze on the tall grass, and giraffes browse on the trees.

## 3. Grassland Biomes

Grasses, like conifers, appear in a variety of settings and are part of many diverse plant communities. They are in fact an initial form in most plant successions. However, there are enormous, continuous expanses of grasslands on Earth. In general, it is thought that grasses are dominant only where trees and shrubs cannot maintain themselves because of either excessive or

deficient moisture in the soil. On the global scale, grassland biomes are located in continental interiors where most, if not all, of the precipitation falls in the summer. Two great geographic realms of grasslands are generally recognized: the tropical and the middle-latitude grasslands. However, it is difficult to define grasslands of either type using any specific climatic parameter.

### 4. Desert Biome

The desert biome is recognized by the presence of plants that are either drought resisting or drought evading includes plants that can survive a moderate to severe water shortage called xerophytes. Plants that have evolved mechanisms to combat drought are known as xerophytes. They are perennial shrubs whose root systems below ground are much more extensive than their visible parts or that have evolved tiny leaves with a waxy covering to combat transpiration. They may have leaves that are needlelike or trunks and limbs that photosynthesize like leaves or that have expandable tissues or accordion-like stems to store water when it is plentiful. The plant cover is usually sparse, with considerable bare ground dotted by a scattering of individual plants.

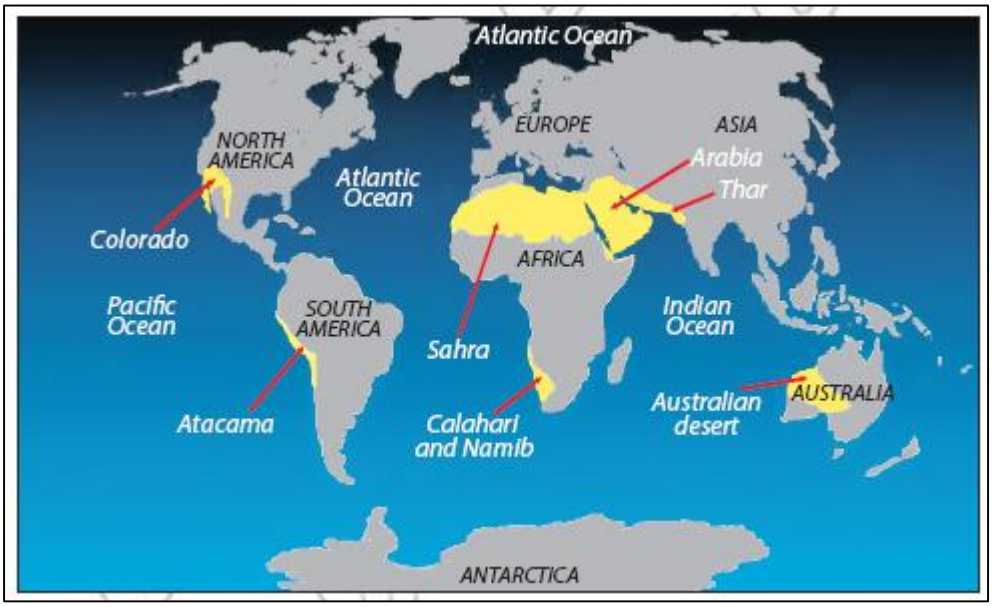


Figure 10: Deserts of the World

### 5. Tundra Biome

Is commonly found in the Polar Regions where the temperature is extremely low as well as at the top of mountains within the tropical and temperate areas (called alpine tundra). The Tundra is essentially a cold desert or grass land in which moisture is scarce and summers so short and cool that trees are unable to survive. This biome is distributed along the northern edge of the Northern hemisphere continents. Many of the plant cover include grasses, mosses, lichens, flowering herbs, and a scattering of low shrubs.

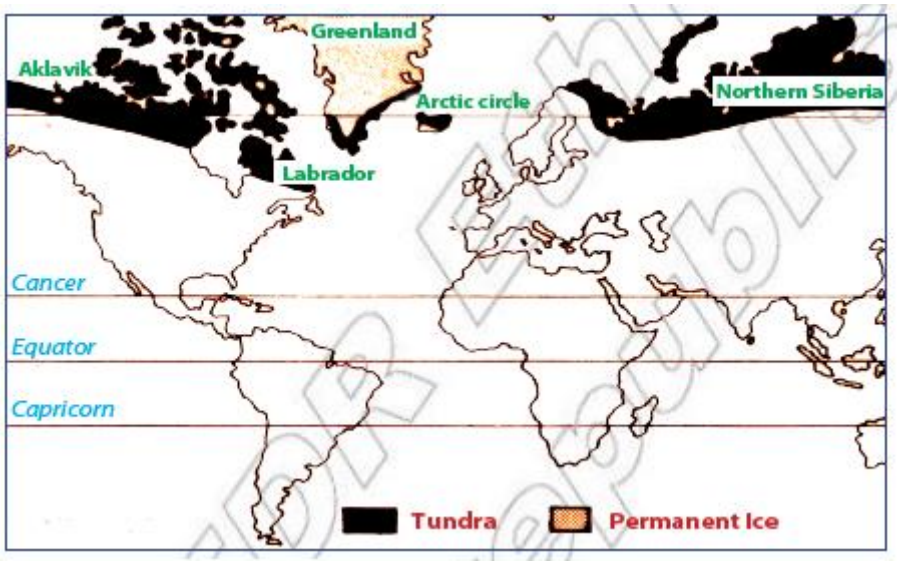


Figure 11: Tundra

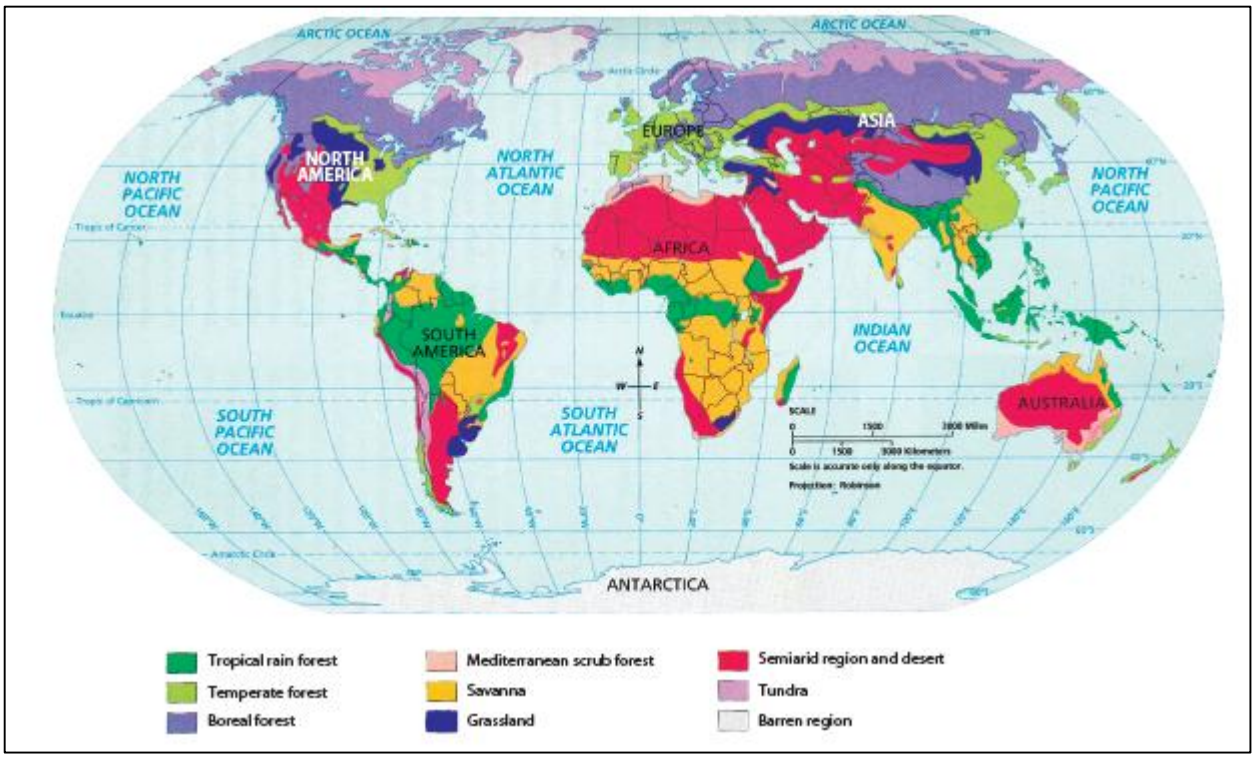


Figure 12: Basic Biomes of the World

## 3.3 Ecological Role of Forest

?*Dear learners; what ecological roles do forests have?* (Use the space below for your answer)

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- Forests provide an environment for many species of plants and animals thus protects and sustains the diversity of nature.
- Plants provide habitat to different types of organisms. Birds build their nests on the branches of trees, animals and birds live in the hollows, insects and other organisms live in various parts of the plant.
- Forests act as hydrologic flow modulators

- Plants provide a protective canopy that lessens the impact of raindrops on the soil, thereby reducing soil erosion. Roots help to hold the soil in place. They provide shade which prevents the soil to become too dry. Thus increases the soil moisture holding capacity.
- Forests help in maintaining microclimate of the area.
- Plants clean the air, cool it on hot days, conserve heat at night, and act as excellent sound absorbers. Transpiration from the forests affects the relative humidity and precipitation in a place. Forests clean the environment by muffling noises, buffering strong winds and stopping dust and gases.
- The layer of leaves that fall around the tree prevents runoff and allows the water to percolate into the soil. Thus helping in ground water recharge.
- Dead plants decompose to form humus, organic matter that holds the water and provides nutrients to the soil.
- Through the process of photosynthesis, forests renew the oxygen supply in the atmosphere by absorbing atmospheric $CO_2$ and moderating the greenhouse effect.
- Forest cover of an area plays an important role in amount of precipitation received by the area. Thus play an important role in maintaining water cycle of the area.
- Some species of trees have the ability to return nitrogen to the soil through root decomposition or fallen leaves. Such trees are planted to increase the nitrogen content of the soil.
- Forests absorb suspended particles in air thereby reducing pollution.
- Forests also helps in the process of soil formation by causing weathering of rock
- They play vital role in maintaining healthy watershed. Rivers originate in a forest area and carry the organic matter from forest to the downstream thus supporting a variety of fishes and aquatic animals. The richness of forest in upstream decides the biological value of the river ecosystem supported by it.
- It provides forest food which has great medicinal value and used by local people in respective season

## 3.4 Causes of Degradation of Natural Vegetation

？*What are the major causes for natural vegetation degradation? How can it be reserved?*

(Use the space below for your answer)

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People are capable of extracting extraordinary influences on the distribution of plants and animals. Not only is the magnitude of the changes likely to be great, but also the speed with which they are affected is sometimes exceedingly rapid. Humankind exerts three types of direct influences on biotic distribution; physical removal of organisms, habitat modification and artificial translocation of organisms.

- **Physical Removal of Organisms**: - As human population increases and spreads over the globe, there is often a wholesale removal of native plants and animals to make way for the severely modified landscape that is thought necessary for civilization. The natural plant and animal inhabitants are cut down, paved over, burned, poisoned, shot, trapped, and otherwise eradicated in actions that have far-reaching effects on overall distribution patterns.

- **Habitat Modification**: - habitat modification is another activity in which humankind excels. The soil environment is changed by farming, grazing, engineering, and construction practices; the atmospheric environment is degraded by the introduction of impurities of various kinds; the waters of the plant are impounded, diverted, and polluted. All these deeds influence the native plants and animals in the affected areas.

- **Artificial Translocation of Organisms**: - people are capable of elaborated rearrangement of the natural complement of plants and animals in almost every part of the world. This is shown clearly with domesticated species-crops and livestock. Forest destruction occurs when locals clear forests for their personal needs, like fuel,

hunting, agriculture, housing development, etc. The main causes of deforestation include population pressure (expansion of agricultural land), overgrazing, and timber cutting for construction, fuel and wildfire.

- **Population Pressure: -** The need for cultivated land, wood for fuel and wood for construction materials increased with rapidly growing population. Tropical forests are cleared for the cultivation of plantation cash crops.

- **Commercial Logging: -** is another major reason for the destruction of forest mainly for export purpose. Shifting cultivation, which is mainly practiced in tropical areas, is a threat for the tropical rainforests.

- **Over Grazing: -** The wood biomass resources of the woodland and bush lands have been rapidly depleted by an increase in the livestock population. Over grazing mainly by ruminants cause irreparable damage to young seedlings. The demands of the international beef industry have led to the clearing of vast areas of rainforest for cattle ranching particularly in Central and Southern America.
- **Cash Crop Economy (expansion of plantation agriculture):** - when best land is taken to earn export income, farmers are forced on to marginal lands resulting in deforestation, land degradation and poverty.

- **Mining and Dams**: mining, industrial development, road construction and hydroelectric schemes are significant causes of deforestation.

- **Wildfires *("seded isat")*:-** Clearing and burning of forests and woodland savannas during the dry season for the expansion of cultivable and grazing land, for charcoal production and for honey production has been one of the major causes of deforestation.

## 3.5 Consequences of Deforestation

### 1. Environmental Impact

#### a. Atmospheric

Deforestation is ongoing and is shaping climate and geography. Deforestation is a contributor to global warming, and is often cited as one of the major causes of the enhanced greenhouse effect. Tropical deforestation is responsible for approximately 20% of world greenhouse gas emissions. According to the Intergovernmental Panel on Climate Change deforestation, mainly in tropical areas, could account for up to one-third of total anthropogenic dioxide emissions. But recent calculations suggest that carbon dioxide emissions from deforestation and forest degradation (excluding peatland emissions) contribute about 12% of total anthropogenic carbon dioxide emissions with a range from 6 to 17%.Deforestation causes carbon dioxide to linger in the atmosphere. As carbon dioxide accrues, it produces a layer in the atmosphere that traps radiation from the sun. The radiation converts to heat which causes global warming, which is better known as the greenhouse effect.

Plants remove carbon in the form of carbon dioxide from the atmosphere during the process of photosynthesis, but release some carbon dioxide back into the atmosphere during normal respiration. Only when actively growing can a tree or forest remove carbon, by storing it in plant tissues. Both the decay and burning of wood releases much of this stored carbon back to the atmosphere. In order for forests to take up carbon, there must be a net accumulation of wood.

One way is for the wood to be harvested and turned into long-lived products, with new young trees replacing them. Deforestation may also cause carbon stores held in soil to be released. Forests can be either sinks or sources depending upon environmental circumstances.

Mature forests alternate between being net sinks and net sources of carbon dioxide (see carbon dioxide sink and carbon cycle)

In deforested areas, the land heats up faster and reaches a higher temperature, leading to localized upward motions that enhance the formation of clouds and ultimately produce more rainfall. However, according to the Geophysical Fluid Dynamics Laboratory, the models used to investigate remote responses to tropical deforestation showed a broad but mild temperature increase all through the tropical atmosphere. The model predicted <0.2 °C warming for upper air at 700 mb and 500 mb. However, the model shows no significant changes in other areas besides the Tropics. Though the model showed no significant changes to the climate in areas other than the Tropics, this may not be the case since the model has possible errors and the results are never absolutely definite.

Fires on Borneo and Sumatra, 2006. People use slash-and-burn deforestation to clear land for agriculture. Reducing emissions from deforestation and forest degradation (REDD) in developing countries has emerged as a new potential to complement ongoing climate policies. The idea consists in providing financial compensations for the reduction of greenhouse gas (GHG) emissions from deforestation and forest degradation".

Rainforests are widely believed by laymen to contribute a significant amount of the world's oxygen, although it is now accepted by scientists that rainforests contribute little net oxygen to the atmosphere and deforestation has only a minor effect on atmospheric oxygen levels. However, the incineration and burning of forest plants to clear land releases large amounts of $CO_2$, which contributes to global warming.Scientists also state that tropical deforestation releases 1.5 billion tons of carbon each year into the atmosphere.

**b. Hydrological**

The water cycle is also affected by deforestation. Trees extract groundwater through their roots and release it into the atmosphere. When part of a forest is removed, the trees no longer transpire this water, resulting in a much drier climate. Deforestation reduces the content of water in the soil and groundwater as well as atmospheric moisture. The dry soil leads to lower water intake for the trees to extract.Deforestation reduces soil cohesion, so that erosion, flooding and landslides ensue. Shrinking forest cover lessens the landscape's capacity to intercept, retain and transpire precipitation. Instead of trapping precipitation, which then percolates to groundwater systems, deforested areas become sources of surface water runoff, which moves much faster than subsurface flows.

That quicker transport of surface water can translate into flash flooding and more localized floods than would occur with the forest cover. Deforestation also contributes to decreased evapotranspiration, which lessens atmospheric moisture which in some cases affects precipitation levels downwind from the deforested area, as water is not recycled to downwind forests, but is lost in runoff and returns directly to the oceans. According to one study, in deforested north and northwest China, the average annual precipitation decreased by one third between the 1950s and the 1980s.

Trees, and plants in general, affect the water cycle significantly:

- Their canopies intercept a proportion of precipitation, which is then evaporated back to the atmosphere (canopy interception);
- Their litter, stems and trunks slow down surface runoff;
- Their roots create macropores – large conduits – in the soil that increase infiltration of water;
- They contribute to terrestrial evaporation and reduce soil moisture via transpiration;
- Their litter and other organic residue change soil properties that affect the capacity of soil to store water.
- Their leaves control the humidity of the atmosphere by transpiring. 99% of the water absorbed by the roots moves up to the leaves and is transpired.

As a result, the presence or absence of trees can change the quantity of water on the surface, in the soil or groundwater, or in the atmosphere. This in turn changes erosion rates and the availability of water for either ecosystem functions or human services. The forest may have little impact on flooding in the case of large rainfall events, which overwhelm the storage capacity of forest soil if the soils are at or close to saturation. Tropical rainforests produce about 30% of our planet's fresh water.

**c. Soil**

Undisturbed forests have a very low rate of soil loss, approximately 2 metric tons per square kilometer (6 short tons per square mile). Deforestation generally increases rates of soil erosion, by increasing the amount of runoff and reducing the protection of the soil from tree litter. This can be an advantage in excessively leached tropical rain forest soils. Forestry operations themselves also increase erosion through the development of roads and the use of mechanized equipment. China's Loess Plateau was cleared of forest millennia ago. Since then it has been eroding, creating dramatic incised valleys, and providing the sediment that gives the Yellow River its yellow color and that causes the flooding of the river in the lower reaches (hence the river's nickname 'China's sorrow').

Removal of trees does not always increase erosion rates. In certain regions of southwest US, shrubs and trees have been encroaching on grassland. The trees themselves enhance the loss of grass between tree canopies. The bare inter canopy areas become highly erodible. The US Forest Service, in Bandelier National Monument for example, is studying how to restore the former ecosystem, and reduce erosion, by removing the trees. Tree roots bind soil together, and if the soil is sufficiently shallow they act to keep the soil in place by also binding with underlying bedrock. Tree removal on steep slopes with shallow soil thus increases the risk of landslides, which can threaten people living nearby.

**d. Biodiversity**

Deforestation on a human scale results in decline in biodiversity, and on a natural global scale is known to cause the extinction of many species. The removal or destruction of areas of forest cover has resulted in a degraded environment with reduced biodiversity Forests support biodiversity, providing habitat for wildlife;] moreover, forests foster medicinal conservation. With forest biotopes being irreplaceable source of new drugs (such as taxol), deforestation can destroy genetic variations (such as crop resistance) irretrievably. Since the tropical rainforests are the most diverse ecosystems on Earthand about 80% of the world's known biodiversity could be found in tropical rainforests, removal or destruction of significant areas of forest cover has resulted in a degraded environment with reduced biodiversity. A study in Rondônia, Brazil, has shown that deforestation also removes the microbial community which is involved in the recycling of nutrients, the production of clean water and the removal of pollutants.

It has been estimated that we are losing 137 plant, animal and insect species every single day due to rainforest deforestation, which equates to 50,000 species a year. Others state that tropical rainforest deforestation is contributing to the ongoing Holocene mass extinction. The known extinction rates from deforestation rates are very low, approximately 1 species per year from mammals and birds which extrapolates to approximately 23,000 species per year for all species. Predictions have been made that more than 40% of the animal and plant species in Southeast Asia could be wiped out in the 21st century. Such predictions were called into question by 1995 data that show that within regions of Southeast Asia much of the original forest has been converted to monospecific plantations, but that potentially endangered species are few and tree flora remains widespread and stable.

Scientific understanding of the process of extinction is insufficient to accurately make predictions about the impact of deforestation on biodiversity. Most predictions of forestry related biodiversity loss are based on species-area models, with an underlying assumption that as the forest declines species diversity will decline similarly. However, many such models have been proven to be wrong and loss of habitat does not necessarily lead to large

scale loss of species. Species-area models are known to over predict the number of species known to be threatened in areas where actual deforestation is ongoing, and greatly over predict the number of threatened species that are widespread. A recent study of the Brazilian Amazon predicts that despite a lack of extinctions thus far, up to 90 percent of predicted extinctions will finally occur in the next 40 years.

## 2. Economic Impact

Damage to forests and other aspects of nature could halve living standards for the world's poor and reduce global GDP by about 7% by 2050, a report concluded at the Convention on Biological Diversity (CBD) meeting in Bonn. Historically, utilization of forest products, including timber and fuel wood, has played a key role in human societies, comparable to the roles of water and cultivable land. Today, developed countries continue to utilize timber for building houses, and wood pulp for paper. In developing countries almost three billion people rely on wood for heating and cooking.

The forest products industry is a large part of the economy in both developed and developing countries. Short-term economic gains made by conversion of forest to agriculture, or over-exploitation of wood products, typically leads to loss of long-term income and long-term biological productivity. West Africa, Madagascar, Southeast Asia and many other regions have experienced lower revenue because of declining timber harvests. Illegal logging causes billions of dollars of losses to national economies annually.

The new procedures to get amounts of wood are causing more harm to the economy and overpower the amount of money spent by people employed in logging. According to a study, "in most areas studied, the various ventures that prompted deforestation rarely generated more than US$5 for every ton of carbon they released and frequently returned far less than US$1". The price on the European market for an offset tied to a one-ton reduction in carbon is 23 euro (about US$35).

Rapidly growing economies also have an effect on deforestation. Most pressure will come from the world's developing countries, which have the fastest-growing populations and most

rapid economic (industrial) growth. In 1995, economic growth in developing countries reached nearly 6%, compared with the 2% growth rate for developed countries. As our human population grows, new homes, communities, and expansions of cities will occur. Connecting all of the new expansions will be roads, a very important part in our daily life. Rural roads promote economic development but also facilitate deforestation. About 90% of the deforestation has occurred within 100 km of roads in most parts of the Amazon. The European Union is one of the largest importer of products made from illegal deforestation.

## 3.6 Conservation and Management of Natural Vegetation

### 1. Reducing Emissions

Main international organizations including the United Nations and the World Bank, have begun to develop programs aimed at curbing deforestation. The blanket term Reducing Emissions from Deforestation and Forest Degradation (REDD) describes these sorts of programs, which use direct monetary or other incentives to encourage developing countries to limit and/or roll back deforestation. Funding has been an issue, but at the UN Framework Convention on Climate Change (UNFCCC) Conference of the Parties-15 (COP-15) in Copenhagen in December 2009, an accord was reached with a collective commitment by developed countries for new and additional resources, including forestry and investments through international institutions, that will approach USD 30 billion for the period 2010–2012. Significant work is underway on tools for use in monitoring developing country adherence to their agreed REDD targets. These tools, which rely on remote forest monitoring using satellite imagery and other data sources, include the Center for Global Development's FORMA (Forest Monitoring for Action) initiative and the Group on Earth Observations' Forest Carbon Tracking Portal. Methodological guidance for forest monitoring was also emphasized at COP-15.

The environmental organization Avoided Deforestation Partners leads the campaign for development of REDD through funding from the U.S. government. In 2014, the Food and

Agriculture Organization of the United Nations and partners launched Open Foris - a set of open-source software tools that assist countries in gathering, producing and disseminating information on the state of forest resources. The tools support the inventory lifecycle, from needs assessment, design, planning, field data collection and management, estimation analysis, and dissemination. Remote sensing image processing tools are included, as well as tools for international reporting for Reducing emissions from deforestation and forest degradation (REDD) and MRVand FAO's Global Forest Resource Assessments.

In evaluating implications of overall emissions reductions, countries of greatest concern are those categorized as High Forest Cover with High Rates of Deforestation (HFHD) and Low Forest Cover with High Rates of Deforestation (LFHD). Afghanistan, Benin, Botswana, Burma, Burundi, Cameroon, Chad, Ecuador, El Salvador, Ethiopia, Ghana, Guatemala, Guinea, Haiti, Honduras, Indonesia, Liberia, Malawi, Mali, Mauritania, Mongolia, Namibia, Nepal, Nicaragua, Niger, Nigeria, Pakistan, Paraguay, Philippines, Senegal, Sierra Leone, Sri Lanka, Sudan, Togo, Uganda, United Republic of Tanzania, Zimbabwe are listed as having Low Forest Cover with High Rates of Deforestation (LFHD). Brazil, Cambodia, Democratic Peoples Republic of Korea, Equatorial Guinea, Malaysia, Solomon Islands, Timor-Leste, Venezuela, and Zambia are listed as High Forest Cover with High Rates of Deforestation (HFHD).

## 2. Payments for Conserving Forests

In Bolivia, deforestation in upper river basins has caused environmental problems, including soil erosion and declining water quality. An innovative project to try and remedy this situation involves landholders in upstream areas being paid by downstream water users to conserve forests. The landholders receive US$20 to conserve the trees, avoid polluting livestock practices, and enhance the biodiversity and forest carbon on their land. They also receive US$30, which purchases a beehive, to compensate for conservation for two hectares of water-sustaining forest for five years. Honey revenue per hectare of forest is US$5 per year, so within five years, the landholder has sold US$50 of honey.

## 3. Farming

New methods are being developed to farm more intensively, such as high-yield hybrid crops, greenhouse, autonomous building gardens, and hydroponics. These methods are often dependent on chemical inputs to maintain necessary yields. In cyclic agriculture, cattle are grazed on farm land that is resting and rejuvenating. Cyclic agriculture actually increases the fertility of the soil. Intensive farming can also decrease soil nutrients by consuming at an accelerated rate the trace minerals needed for crop growth. The most promising approach, however, is the concept of food forests in permaculture, which consists of agro-forestall systems carefully designed to mimic natural forests, with an emphasis on plant and animal species of interest for food, timber and other uses. These systems have low dependence on fossil fuels and agro-chemicals, are highly self-maintaining, highly productive, and with strong positive impact on soil and water quality, and biodiversity.

## 4. Monitoring Deforestation

There are multiple methods that are appropriate and reliable for reducing and monitoring deforestation. One method is the "visual interpretation of aerial photos or satellite imagery that is labor-intensive but does not require high-level training in computer image processing or extensive computational resources". Another method includes hot-spot analysis (that is, locations of rapid change) using expert opinion or coarse resolution satellite data to identify locations for detailed digital analysis with high resolution satellite images. Deforestation is typically assessed by quantifying the amount of area deforested, measured at the present time. From an environmental point of view, quantifying the damage and its possible consequences is a more important task, while conservation efforts are more focused on forested land protection and development of land-use alternatives to avoid continued deforestation. Deforestation rate and total area deforested, have been widely used for monitoring deforestation in many regions, including the Brazilian Amazon deforestation monitoring by INPE.

## 5. Reforestation

In many parts of the world, especially in East Asian countries, reforestation and afforestation are increasing the area of forested lands.The amount of woodland has increased in 22 of the world's 50 most forested nations. Asia as a whole gained 1 million hectares of forest between 2000 and 2005. Tropical forest in El Salvador expanded more than 20% between 1992 and 2001. Based on these trends, one study projects that global forest will increase by 10% an area the size of India by 2050. In the People's Republic of China, where large scale destruction of forests has occurred, the government has in the past required that every able-bodied citizen between the ages of 11 and 60 plant three to five trees per year or do the equivalent amount of work in other forest services. The government claims that at least 1 billion trees have been planted in China every year since 1982. This is no longer required today, but March 12 of every year in China is the Planting Holiday. Also, it has introduced the Green Wall of China project, which aims to halt the expansion of the Gobi desert through the planting of trees. However, due to the large percentage of trees dying off after planting (up to 75%), the project is not very successful. There has been a 47-million-hectare increase in forest area in China since the 1970s the total number of trees amounted to be about 35 billion and 4.55% of China's land mass increased in forest coverage. The forest coverage was 12% two decades ago and now is 16.55%.

An ambitious proposal for China is the Aerially Delivered Re-forestation and Erosion Control System and the proposed Sahara Forest Project coupled with the Seawater Greenhouse. In Western countries, increasing consumer demand for wood products that have been produced and harvested in a sustainable manner is causing forest landowners and forest industries to become increasingly accountable for their forest management and timber harvesting practices. The Arbor Day Foundation's Rain Forest Rescue program is a charity that helps to prevent deforestation. The charity uses donated money to buy up and preserve rainforest land before the lumber companies can buy it. The Arbor Day Foundation then protects the land from deforestation. This also locks in the way of life of the primitive tribes living on the forest land. Organizations such as Community Forestry International, Cool Earth, The Nature Conservancy, World Wide Fund for Nature, Conservation International, African Conservation

Foundation and Greenpeace also focus on preserving forest habitats. Greenpeace in particular has also mapped out the forests that are still intactand published this information on the internet World Resources Institute in turn has made a simpler thematic mapshowing the amount of forests present just before the age of man (8000 years ago) and the current (reduced) levels of forest. These maps mark the amount of afforestation required to repair the damage caused by people.

**Summary**

The term natural vegetation is commonly used to describe the natural growth of plants as distinct from the cultivated plant growth, which covers the earth's surface. The occurrence, nature and type of natural vegetation in any area are influenced by a variety of factors like climate, edaphic factors, physiographic (like structure, relief, altitude, slope, and aspect), biotic and human influence due to clearance, burning, drainage etc. Biomes is the largest recognizable subdivision within the terrestrial ecosystem or large ecosystems dominated by one major type of vegetation and the major vegetation biomes of the world are forest biome, the savanna biome, grassland biome, the desert biome and the tundra biome.

Vegetation has an important role in maintaining the productivity of the environment; trees provide food for animals, a standing cover to protect the land from wind and water erosion, stabilizing the water cycle, facilitates the process of evaporation and keeps the soil porous etc. They also used for construction as well as for tools, furniture, for fuel, medicine, grass and herbage for forage and provide edible fruits. They serve for absorbing carbon-dioxide so that reduce global warming, give off oxygen, renewing the atmosphere. Plants also serve as source of income by attracting tourists-serve as recreational facilities; prevent lakes and dams from silting; clean, regulate and distribute water resources. Forests control water discharge (decreases the run off, facilitate infiltration). Products of trees also serve as source of income like gums, resins, pulp paper, plywood, fibers etc.

Forest destruction occurs when locals clear forests for their personal needs, like fuel, hunting, agriculture, housing development, etc. The main causes of deforestation include population pressure (expansion of agricultural land), overgrazing, and timber cutting for construction, fuel and wildfire. Deforestation results in many negative socio-economic and ecological effects like destruction of bio-diversity; desiccation (aridness) of previously moist forest soil; depletion of ground water, global warming, change of

micro/macro climate and in hydrological cycles; causes the disappearance of wild animals, birds and reptiles; affects the natural beauties of area and accelerates run off and soil erosion. So, efforts are required to encourage sustainable forest management, balancing environmental, social and economic objectives.

**Check list**

Dear learner, now this chapter is over. Put ( ✓) mark in the box against each of the following points if you are sure of it and (×) mark if you are not sure of it. If you put (✓) mark for each case, do the activity followed by the check list and proceed to the next chapter. If there is any (× ) mark, please return back to that issue before proceeding to the next part of the course.

I can:

| | | |
|---|---|---|
| 1 | Identify the factors that determine the type of natural vegetation in an area | ☐ |
| 2 | Explain the prominent characteristics of the major vegetation types of The world | ☐ |
| 3 | Discuss the basic features of the major forest biome of the world | ☐ |
| 4 | Mention the significances of forest resources | ☐ |
| 5 | Explain the major forms of vegetation deterioration | ☐ |
| 6 | Identify and explain the major causes of vegetation degradation | ☐ |
| 7 | Elaborate the adverse effects of vegetation degradation | ☐ |
| 8 | Explain the major conservation and management mechanism of Natural vegetation resources | ☐ |

**Exercise 3:**

1. What is deforestation?
2. Give two reasons why trees are cut down by humans.
3. State any two consequences of deforestation.
4. Why do wild animals become endangered due to deforestation?
5. Why does deforestation cause soil erosion?

# CHAPTER FOUR

# 4. RANGELAND RESOURCES

**Contents:**



**Objectives:**

✧ **After the completion of this chapter, learners will be able to:**

- Define Rangelands
- Discuss Classifications of Rangelands
- Describe Rangelands of the World
- Explain uses of rangelands
- State rangeland problems
- Elaborate the Conservation and Management of rangelands

## 4.1 Rangeland, Definition and Concepts

?*Dear learners; Have you ever heard about rangelands? What is rangeland?* (Use the space below for your answer)

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The United States Environmental Protection Agency (EPA) defines rangeland as "lands on which the native vegetation (climax or natural potential plant community) is predominantly grasses, grass-like plants, forbs, or shrubs suitable for grazing or browsing use. The EPA classifies natural grassland and savannas as rangeland, and in some cases includes wetlands, deserts, tundra, and "certain forb and shrub communities. The primary difference between rangeland and pasture is management; rangelands tend to have natural vegetation along with a few introduced plant species, but all managed by grazing, while pastures have forage that is adapted for livestock and managed, by seeding, mowing, fertilization and irrigation.

Rangelands are extensive tracts of lands that are essentially unsuited to rain fed crop cultivation, industrial forestry, protected forests or urbanization but naturally produce forage plants suitable for grazing and browsing (grazing is consumption of standing forages like grasses and forbs while browsing is consumption of edible leaves and woody plants). Rangelands are not suitable for crop cultivation mainly because of the physical limitations such as low precipitation, very shallow soils, very steep and rough topography, poor drainage or cold climate. However, they are very important resources since they provide important forage for domestic livestock and wild animals. Some rangelands also support many species of wild life that provide a reservoir of genetic diversity. Rangelands can also produce intangible products such as natural beauty, open space and wilderness that satisfy important societal values and provide recreational opportunities. Rangeland, in general, refers to expansive, mostly unimproved lands on which a significant proportion of the natural vegetation is native grasses, grass-like plants, forbs, and

shrubs. Rangelands include natural grasslands, savannas, shrub lands, many deserts, tundra, alpine communities, coastal marshes, and wet meadows. Rangeland is generally arid, semi-arid, sub-humid or otherwise unsuitable for cultivation. Range lands are characterized by low amount of precipitation (mostly less than 500 mm per year), high rainfall variability and the ecology is particularly fragile.

The rangelands are also ecologically important because of the significant number of endemic species, high species diversity, areas of ecological and geomorphological integrity, unique ecosystems and habitat for rare, threatened and endangered species. With the benefit of hindsight there is now an appreciation that past management practices and some current ones have, in many areas, proved inappropriate to the rangelands. These practices have resulted in accelerated soil erosion, increased numbers and distribution of weeds and feral (untamed) animals, reduced water quality, soil salinity, the decline of and changes to native plant communities, and decreased biodiversity. This has led to significant areas of the rangelands being degraded, calling into question on their long term sustainability under current use.

## 4.2 Types of Rangeland

### i. Prairie

Prairies are considered part of the temperate grasslands, savannas and shrub lands biome by ecologists, based on similar temperate climates, moderate rainfall, and grasses, herbs, and shrubs, rather than trees, as the dominant vegetation type. Temperate grassland regions include the Pampas of Argentina, and the steppes of Eurasia.

### ii. Grasslands

Grasslands are areas where the vegetation is dominated by grasses (Poaceae) and other herbaceous (non-woody) plants (forbs). However, sedge (Cyperaceae) and rush (Juncaceae) families can also be found. Grasslands occur naturally on all continents except Antarctica. In temperate latitudes, such as northwest Europe and the Great Plains and California in North

America, native grasslands are dominated by perennial bunch grass species, whereas in warmer climates annual species form a greater component of the vegetation.

### iii. Steppe

Steppe, in physical geography, refers to a biome region characterized by grassland plain without trees apart from those near rivers and lakes. The prairie (especially the short grass and mixed prairie) is an example of a steppe, though it is not usually called such. It may be semi-desert, or covered with grass or shrubs or both, depending on the season and latitude. The term is also used to denote the climate encountered in regions too dry to support a forest, but not dry enough to be a desert.

### iv. Pampas

Pampas are the fertile South American lowlands that include the Argentine provinces of Buenos Aires, La Pampa, Santa Fe, Entre Ríos and Córdoba, most of Uruguay, and the State of Rio Grande do Sul, in the southernmost end of Brazil covering more than 750,000 $km^2$ (289,577 sq mi). These vast plains are only interrupted by the low Ventana and Tandil hills near Bahía Blanca and Tandil (Argentina), with a height of 1,300 m (4,265 ft) and 500 m (1,640 ft) respectively. The climate is mild, with precipitation of 600 mm (23.6 in) to 1,200 mm (47.2 in), more or less evenly distributed through the year, making the soils appropriate for agriculture. This area is also one of the distinct physiography provinces of the larger Paraná-Paraguay Plain division. These plains contain unique wildlife because of the different terrains around it. Some of this wildlife includes the rhea, the badger, and the prairie chicken.

### v. Shrub land

Shrub land is a plant community characterized by vegetation dominated by shrubs, often also including grasses, herbs, and geophytes. Shrub land may either occur naturally or be the result of human activity. It may be the mature vegetation type in a particular region and remain stable over time, or a transitional community that occurs temporarily as the result of a disturbance, such as fire. A stable state may be maintained by regular natural disturbance such as fire or browsing.

Shrub land may be unsuitable for human habitation because of the danger of fire. The term "shrub land" was first coined in 1903.

### vi. Woodland

Woodland is a low-density forest forming open habitats with plenty of sunlight and limited shade. Woodlands may support an understory of shrubs and herbaceous plants including grasses. Woodland may form a transition to shrub land under drier conditions or during early stages of primary or secondary succession. Higher densities and areas of trees, with largely closed canopy, provide extensive and nearly continuous shade are referred to as forest.

### vii. Savanna

Savanna is a grassland ecosystem characterized by the trees being sufficiently small or widely spaced so that the canopy does not close. The open canopy allows sufficient light to reach the ground to support an unbroken herbaceous layer consisting primarily of C4 grasses

### viii. Desert

Desert is a landscape or region that receives an extremely low amount of precipitation, defined as areas with an average annual precipitation of less than 250 millimeters (10 in) per year, or as areas where more water is lost by evapotranspiration than falls as precipitation. In the Köppen climate classification system, deserts are classed as *BWh* (hot desert) or *BWk* (temperate desert). In the Thornthwaite climate classification system, deserts would be classified as arid megathermal climates.

### ix. Tundra

Tundra is a biome where the tree growth is hindered by low temperatures and short growing seasons. There are three types of tundra: Arctic tundra, alpine tundra, and Antarctic tundra. In

tundra, the vegetation is composed of dwarf shrubs, sedges and grasses, mosses, and lichens. Scattered trees grow in some tundra. The ecotone (or ecological boundary region) between the tundra and the forest is known as the tree line or timberline.

## 4.3 Rangelands of the World

### 1. Australia

About 75% of Australia's land mass is Rangeland. 53 of Australia's 85 bioregions have rangelands. In Western Australia, rangelands cover about 87% of the state's 2.5 million square kilometres. Australian Rangelands support significant parts of the nation's economy, including Australia's valuable mining industry ($12 billion/yr), tourism ($2 billion/yr), pastoralism ($5.5 billion/yr – cattle $4.4 billion & sheep $1 billion). Australia's rangelands include a diverse group of relatively undisturbed ecosystems such as; tropical savannas, woodlands, shrub lands, grasslands and deserts. Rangelands in Australia cover low rainfall and variable climates which include; arid semi-arid and seasonally high rainfall areas. Australian rangelands are important in; biodiversity, income, social and cultural heritage, sub-artesian water sources and major river systems, clean and green food and fiber production, and carbon storage. Rangelands contain a wealth of biodiversity including a total of 1800 types of plants and 605 vertebrate animals currently identified. Rangelands are managed by Australia's Department of Agriculture, Fisheries and Forestry (DAFF) and the ESRM Programs on the local level.

### 2. South America

Rangelands in South America are located in regions with climate ranging from arid to sub-humid. Annual precipitation in these areas ranges from approximately 150 to 1500 mm (6–60 inches). Within South America, rangelands cover about 33% of the total land area. South American rangelands include; grasslands, shrub lands, savannas, and hot and cold deserts. Rangelands in South America exclude hyper arid deserts. Examples of the South American rangelands include the; Patagonian Steppe, the Monte, the Pampas, the "Lianos" or "Cerrado," the "Chaco" and the "Caatinga." The change in the intensity and location of tropical

thunderstorms and other weather patterns is the driving force in the climates of southern South America.

3. **Africa**

In Kenya, rangelands make up for 85% of the land surface area, and are largely inhabited by nomadic pastoralists who are largely dependent on livestock. This movement often brings along an incursion of different diseases with the common one being the rinderpest virus in the Kenyan wildlife population from the Somalian ecosystem.

4. **Asia-China**

In the past, rangelands in western China supported a pastoral economy and large wildlife populations. Now the rangelands have shrunk due to population growth, economic, government, and social factors. Rangeland types in China include; Semi-desert, Dry Alpine Grasslands, Alpine Dwarf Shrub, Wetland types.

5. **North America**
    a. **Canada**

Rangeland is a prominent feature of rural Canada. A provincial jurisdiction, administration and policy regarding range use varies across the country. As in many other Commonwealth countries, public tenures on crown land for the purpose of range activities are common in geographically compatible areas. Reconciling the economic needs of ranchers and the need for environmental conservation is one of the primary themes in modern range discourse. In western Canada, both grassland and forested range are significant. In British Columbia, 70 percent of grassland range is privately owned and 60 percent of the total annual livestock forage requirement is provided by grazing on Crown rangeland (34 million hectares), 80 percent of which is forested range. Grassland range predominates in much of the Prairie Provinces' ranching area; however, forested range is particularly important in the boreal region.

Certain rangelands are preserved as provincially-protected areas similar to parks, others are managed as community resources. For example, in Alberta since 2003 there has been legistation allowing the creation of "Heritage Rangelands" within the parks system. As of 2012 there were 2 heritage rangelands and 6 proposed future heritage rangelands run by Alberta Parks. There are also 32 provincial grazing reserves located throughout Alberta administered as public lands by Alberta Sustainable Resource Development. The federal government has administered several "Community Pastures" in Western Canada that were reclaimed lands suffering erosion during the 1930s. In 2012, it was announced that this federal involvement would be phased out over a six-year period.

### b. United States

Of the land within the United States borders, 36% is considered rangelands. The western side of the United States is 53% rangeland. Around 399 million acres (1,610,000 km²) of rangeland are privately owned. The Bureau of Land Management manages about 167 million acres (676,000 km²) of publicly owned rangeland, with the United States Forest Service managing approximately 95 million acres (380,000 km²) more. Ranchers may lease portions of this public rangeland and pay a fee based on the number and type of livestock and the period for which they are on the land.

Historically much of the land in the western United States was used for grazing and much of some states still is. In many of those states, such as Arizona, an open-range law applies which requires a land owner to fence cattle out rather than in; thus cattle are theoretically allowed to roam free. In modern times open-range laws can conflict with urban development as occasional stray cows, bulls, or even herds wander into subdivisions or onto highways.

## 4.4 Uses of Rangelands

Rangelands produce a wide variety of goods and services desired by society, including livestock forage (Grazing), wildlife habitat, water, resources, wood, wild land, open space and natural

beauty. The geographic extent and many important resources of rangelands make their proper use and management vitally important to people everywhere.

## 4.5 Problems of Rangeland Resources

? *Dear learners; what are the major problems related with rangelands in your locality?* (Use the space below for your answer)

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The most common problem related to rangeland resources include:-

- **Desertification**: - (the expansion of deserts) due to human activities like uncontrolled grazing, burning, wood cutting, cultivation etc.
- **Drought**: - shortage of rainfall that result in declining of forage quantity and quality.
- **Poisonous Plant Problems**:- which cause poor livestock reproduction and weight gain.
- **Problems of Insects**: - Like Grasshopper, range caterpillars, black grass bugs etc.
- **Problems of Predators**:- have considerable influence on range livestock industry.
- **Communal Resources**:- the tragedy of the commons (in most cases there is no tenure system)
- **Shortage of Drinking Water**
- **Salinization Problem**

## 4.6 Management and Conservation of Rangeland Resources

? *Dear learners; how people in your locality conserve rangeland resources?* (Use the space below for your answer)

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Rangelands are ecologically fragile that needs particular attention. The following strategies help to minimize at least the degradation of rangeland resources.

- Clear and unambiguous roles for all people and organizations with rangeland management responsibilities, should be outlined, including mutual respect, recognition and support for traditional practices where they are appropriate.
- Encourage rangeland businesses to manage change through promoting opportunities for diversification, multiple use and alternative resource use.
- Develop mechanisms for the restoration and future management of degraded lands
- Promote opportunities for alternative or multiple uses of areas held as a common resource, consistent with the principles of ecologically sustainable management.
- State and Territory Governments should provide clarification of tenure and access to resources to enable users and managers to make appropriate investment and management decisions for ecologically sustainable rangeland management including business viability.
- Land capability assessment must be the basis for all land use planning in the rangelands.
- Government agencies and training providers should develop training programs in business and financial skills, share available knowledge on best practice in ecologically sustainable rangeland management and encourage acquisition by rangeland communities of broader management skills.

- Extension services should be tailored to the rangeland environment needs in collaboration with regional groups and managers.
- Governments should examine options for affordable access for remote and isolated rangeland managers and users to telecommunications technology relevant to their business needs.
- Financial and other institutions that plan and deliver services should be sensitive to the ecological time scale, the climatic variability and the regional differences in the rangelands which affect production levels and take into account the variability of commodity prices.
- The negative impacts of mining, tourism and other industries on rangeland resources should be minimized and adequate rehabilitation of rangelands affected by these activities should occur.
- Self-reliant rural towns are required to provide economic and social focal points for rangeland communities and access to improved social services.
- Surface and groundwater resources of the rangelands should be managed in a sustainable manner to ensure long-term quality and availability.
- Regional planning should be flexible and responsive to the ongoing and changing needs of rangeland communities, managers and the environment.
- There needs to be an effective program of strategic and adaptive research, development and extension, with direct involvement by rangeland users, managers and communities.

**Summary**

Rangelands are extensive tracts of lands that are essentially unsuited to rain fed crop cultivation, industrial forestry, protected forests or urbanization but naturally produce forage plants suitable for grazing and browsing. Rangeland, in general, refers to expansive, mostly unimproved lands on which a significant proportion of the natural vegetation is native grasses, grass-like plants, forbs, and shrubs. Rangelands include natural grasslands, savannas, shrub lands, many deserts, tundra, alpine communities, coastal marshes, and wet meadows. Range lands are very important resources since they provide important forage for domestic livestock and wild animals; support

many species of wild life that provide a reservoir of genetic diversity; produce intangible products such as natural beauty, open space and wilderness that satisfy important societal values and provide recreational opportunities.

The rangelands are also ecologically important because of the significant number of endemic species, high species diversity, areas of ecological and geomorphologic integrity, unique ecosystems and habitat for rare, threatened and endangered species.

The most common problem related to rangeland resources include desertification due to human activities like uncontrolled grazing, burning, wood cutting, cultivation; drought – shortage of rainfall that result in declining of forage quantity and quality; poisonous plant problems - which cause poor livestock reproduction and weight gain; problems of insects like grasshopper, range caterpillars, black grass bugs etc.; shortage of drinking water for their livestock; and salinization problems. Rangelands are ecologically fragile that needs particular attention.

**Check list**

Dear learner, now this chapter is over. Put ( ✓) mark in the box against each of the following points if you are sure of it and (×) mark if you are not sure of it. If you put (✓) mark for each case, do the activity followed by the check list and proceed to the next chapter. If there is any (× ) mark, please return back to that issue before proceeding to the next part of the course.

| I can: | | |
|---|---|---|
| 1 | Define range land | ☐ |
| 2 | Explain the major characteristics of rangelands | ☐ |
| 3 | Mention the importance of rangeland resources | ☐ |
| 4 | Explain why special attention is needed for rangeland resources | ☐ |
| 5 | Mention the main rangelands of the world | ☐ |
| 6 | Identify the major problems related to rangeland resources | ☐ |
| 7 | Explain the basic mechanisms of rangeland resource conservation and management | ☐ |

**Exercise 4:**

1. What is rangeland?
2. Discuss the difference between grass lands and shrub lands.
3. What are the uses of rangelands?
4. What major problems are threatening the world's rangelands?
5. What strategies should be designed to improve rangelands and preserve their sustainability?

# CHAPTER FIVE

# 5. WILDLIFE RESOURCES

**Contents:**



**Objectives:**

- ✧ **Up on the completion of this chapter, learners will be able to:**

- Define Wildlife
- Explain problems of Wildlife
- Describe Conservation and Management of Wildlife
- State the Importance of Wildlife management
- Elaborate the difference between preservation, conservation and management of resources

## 5.1 Wildlife, Definition and Concepts

？*What is Wildlife?* (Use the space below for your answer)

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The term wildlife means different things to different people. To a backyard wildlife enthusiast, it may mean chickadees, nuthatches, and cardinals. To a hunter, it may mean white-tailed deer, bobwhite quail, and gray squirrels. To a sheep producer, it may mean coyotes. To a poultry producer, it may mean mink, weasels, skunks, and raccoons. To a gardener, it may mean hummingbirds and butterflies.

It is important to identify and define what we mean by the term "wildlife" before we can answer the question, "What is wildlife management and conservation?" Early definitions of wildlife focused on wild animals (undomesticated free-ranging animals) that could be hunted for sport or food; therefore, the early definitions restricted the term wildlife to vertebrates (animals with a backbone). From that time forward, the message has been clear: there is a separation of those organisms termed wildlife, not only from other vertebrates, but most certainly from other groups of lower animals and plants.

If you were to ask a professional biologist to define wildlife, he or she would probably identify two distinct vertebrate groups: birds and mammals. Even state and federal organizations, in their names, make a distinction between fish and wildlife: the South Carolina Department of Natural Resources and the U.S. Fish and Wildlife Service.

Much has happened in the field of wildlife management since early times, and this is reflected in new definitions of wildlife based on a more holistic viewpoint. The beginnings of this new viewpoint of wildlife began in the 1960s. Wording in the Endangered Species Act of 1973 recognized fish and wildlife as any member of the animal kingdom, including without limitation any mammal, bird, fish, amphibian, reptile, mollusk, crustacean, arthropod, or otherinvertebrates(animals without a backbone).

About the same time, many states began adopting nongame wildlife programs. These programs were aimed at managing protected, endangered or threatened, and non-hunted wildlife with respect to the definition of fish and wildlife provided in the Endangered Species Act.

From a purely objective standpoint, wildlife should include all animals and their associated habitats. If we are to look at the big picture, it seems unnecessary to define the term wildlife along the usually rigid and nonfunctional lines of ataxonomist (a person who identifies and classifies living organisms).

How can we understand the ecology of a great blue heron without a thorough knowledge of the heron's food source (small minnows, amphibians, etc.)? Likewise, a picture of coyote ecology would be incomplete without an understanding of how that animal's diet shifts from small mammals and carrion in the winter to insects and fruits during the summer. Further, the relationship of an animal to its habitat (including competitors, predators, prey items, vegetation, and soil) is so interconnected as to add confusion in attempts to restrict the term wildlife.

A definition of wildlife should include all living organisms out of the direct control of man, including undomesticated or cultivated plants and animals.

Although it may be inappropriate to restrict wildlife to a few kinds of organisms, common usage, public perceptions, funding allocations, and history have resulted in a practical definition of wildlife as undomesticated free-ranging vertebrates. Furthermore, because of professional distinctions, fish are generally excluded from the definition of wildlife. The definition of **wildlife** is left as essentially undomesticated, free-ranging terrestrial vertebrates (reptiles, amphibians, birds, and mammals).

The overwhelming preponderance of research and management efforts, as well as public attention, has caused the definition of wildlife to focus on birds and mammals.

There is yet another dilemma for resource managers in defining wildlife today: introduced, non-native wildlife or exotics, such as the European starling, house sparrow, wild boar, and fallow deer. Hundreds of plants, fish, and terrestrial animals have been introduced into this country, some by accident and others on purpose. To the wildlife biologist, exotics may have severe consequences for native wildlife (starlings and house sparrows competing for native eastern bluebird nesting sites).

Professional biologists will debate the pros and cons of exotic introductions for years to come. Regardless of an individual's views on the subject, certain exotics will continue to be a permanent addition to our natural communities. Professional biologists must continue to evaluate the ecological role of exotics in biological communities. Hence, if exotics are free-ranging, little is gained from excluding them from a definition of wildlife.

Wildlife traditionally refers to non-domesticated animal species, but has come to include all plants, fungi, and other organisms that grow or live wild in an area without being introduced by humans. Wildlife can be found in all ecosystems. Deserts, forests, rain forests, plains, grasslands, and other areas including the most developed urban sites, all have distinct forms of wildlife. While the term in popular culture usually refers to animals that are untouched by human factors, most scientists agree that much wildlife is affected by human activities.

Humans have historically tended to separate civilization from wildlife in a number of ways including the legal, social, and moral sense. Some animals, however, have adapted to suburban environments. This includes such animals as domesticated cats, dogs, mice, and gerbils. Religions have often declared certain animals to be sacred, and in modern times concern for the natural environment has provoked activists to protest the exploitation of wildlife for human benefit or entertainment.

The global wildlife population has decreased by 52 percent between 1970 and 2014, according to a report by the World Wildlife Fund.

## 5.2 Problems of Wildlife

? *What are the major problems of Wildlife in your locality?* (Use the space below for your answer)

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Exploitation of wild populations has been a characteristic of modern man since our exodus from Africa 130,000 – 70,000 years ago. The rate of extinctions of entire species of plants and animals across the planet has been so high in the last few hundred years it is widely believed that we are in the sixth great extinction event on this planet; the Holocene Mass Extinction. Destruction of wildlife does not always lead to an extinction of the species in question, however, the dramatic loss of entire species across Earth dominates any review of wildlife destruction as extinction is the level of damage to a wild population from which there is no return.

Fewer natural wildlife habitat areas remain each year. Moreover, the habitat that remains has often been degraded to bear little resemblance to the wild areas which existed in the past. Habitat loss due to destruction, fragmentation and degradation of habitat is the primary threat to the survival of wildlife in the United States.

- **Climate Change**: Global warming is making hot days hotter, rainfall and flooding heavier, hurricanes stronger and droughts more severe. This intensification of weather and climate extremes will be the most visible impact of global warming in our everyday lives. It is also causing dangerous changes to the landscape of our world, adding stress to wildlife species and their habitat. Since many types of plants and animals have specific habitat requirements, climate change could cause disastrous loss of wildlife species. A slight drop or rise in average rainfall will translate into large seasonal changes. Hibernating mammals, reptiles, amphibians and insects are harmed and disturbed. Plants and wildlife are sensitive to moisture change so, they will be harmed by

any change in moisture level. Natural phenomena like floods, earthquakes, volcanoes, lightning, forest fires.

- **Unregulated Hunting** and **Poaching**: Unregulated hunting and poaching causes a major threat to wildlife. Along with this, mismanagement of forest department and forest guards triggers this problem.

- **Pollution**: Pollutants released into the environment are ingested by a wide variety of organisms. Pesticides and toxic chemical being widely used, making the environment toxic to certain plants, insects, and rodents.

- **Over Exploitation**: is the over use of wildlife and plant species by people for food, clothing, pets, medicine, sport and many other purposes. People have always depended on wildlife and plants for food, clothing, medicine, shelter and many other needs. But today we are taking more than the natural world can supply. The danger is that if we take too many individuals of a species from their natural environment, the species may no longer be able to survive. The loss of one species can affect many other species in an ecosystem. The hunting, trapping, collecting and fishing of wildlife at unsustainable levels is not something new. The passenger pigeon was hunted to extinction, early in the last century, and over-hunting nearly caused the extinction of the American bison and several species of whales. Perhaps the largest threat is the extreme growing indifference of the public to wildlife, conservation and environmental issues in general. Over-exploitation of resources, i.e., exploitation of wild populations for food has resulted in population crashes (over-fishing and over-grazing for example).

- **Population**: The increasing population of human beings is the most major threat to wildlife. More people on the globe means more consumption of food, water and fuel. Therefore, more waste is generated. Every major threat to wildlife as seen above, is directly related to increasing population of human beings. If the population is altered so is the amount of risk to wildlife. The less is the population, less is the disturbance to wildlife.

The four most general reasons that lead to destruction of wildlife include overkill, habitat destruction and fragmentation, impact of introduced species and chains of extinction.

## 1. Overkill

Overkill happens whenever hunting occurs at rates greater than the reproductive capacity of the population is being exploited. The effects of this are often noticed much more dramatically in slow growing populations such as many larger species of fish. Initially when a portion of a wild population is hunted, an increased availability of resources (food, etc.) is experienced increasing growth and reproduction as density dependent inhibition is lowered. Hunting, fishing and so on, has lowered the competition between members of a population. However, if this hunting continues at rate greater than the rate at which new members of the population can reach breeding age and produce more young, the population will begin to decrease in numbers.

Populations that are confined to islands, whether literal islands or just areas of habitat that are effectively an "island" for the species concerned, have also been observed to be at greater risk of dramatic population declines following unsustainable hunting.

## 2. Habitat Destruction and Fragmentation

The habitat of any given species is considered its preferred area or territory. Many processes associated with human habitation of an area cause loss of this area and decrease the carrying capacity of the land for that species. In many cases these changes in land use cause a patchy break-up of the wild landscape. Agricultural land frequently displays this type of extremely fragmented, or relictual, habitat. Farms sprawl across the landscape with patches of un-cleared woodland or forest dotted in-between occasional paddocks. Examples of habitat destruction include grazing of bush land by farmed animals, changes to natural fire regimes, forest clearing for timber production and wetland draining for city expansion.

## 3. Impact of Introduced Species

Mice, cats, rabbits, dandelions and poison ivy are all examples of species that have become invasive threats to wild species in various parts of the world. Frequently species that are uncommon in their home range become out of control invasions in distant but similar climates. The reasons for this have not always been clear and Charles Darwin felt it was unlikely that exotic species would ever be able to grow abundantly in a place in which they had not evolved. The reality is that the vast majority of species exposed to a new habitat do not reproduce successfully. Occasionally, however, some populations do take hold and after a period of acclimation can increase in numbers significantly, having destructive effects on many elements of the native environment of which they have become part.

**4. Chains of Extinction**

This final group is one of secondary effects. All wild populations of living things have many complex intertwining links with other living things around them. Large herbivorous animals such as the hippopotamus have populations of insectivorous birds that feed off the many parasitic insects that grow on the hippo. Should the hippo die out, so too will these groups of birds, leading to further destruction as other species dependent on the birds are affected.

Also referred to as a domino effect, this series of chain reactions is by far the most destructive process that can occur in any ecological community. Another example is the black drongos and the cattle egrets found in India. These birds feed on insects on the back of cattle, which helps to keep them disease-free. Destroying the nesting habitats of these birds would cause a decrease in the cattle population because of the spread of insect-borne diseases.

## 5.3 Conservation and Management of Wildlife

Wildlife conservation is the practice of protecting wild plant and animal species and their habitats. The goal of wildlife conservation is to ensure that nature will be around for future generations to enjoy and also to recognize the importance of wildlife and wilderness for humans and other species alike.20% of the world's 7~15million species could be extinct in the next 30 years. Do you want that to happen? If not then you should practice wildlife conservation yourself. Many nations have government agencies and NGO's dedicated to wildlife conservation, which help to implement policies designed to protect wildlife. Numerous independent non-profit organizations also promote various wildlife conservation causes.

Wildlife conservation has become an increasingly important practice due to the negative effects of human activity on wildlife. The science of extinction is called dirology. An endangered species is defined as a population of a living species that is in the danger of becoming extinct because of several reasons. Some of The reasons can be, that:

1. The species have a very low population, or
2. They are threatened by the varying environmental or prepositional parameters.

Wildlife management attempts to balance the needs of wildlife with the needs of people using the best available science. Wildlife management can include keeping, wildlife and pest control. Wildlife management draws on disciplines such as mathematics, chemistry, biology, ecology, climatology and geography to gain the best results.

Wildlife conservation aims to halt the loss in the Earth's biodiversity by taking into consideration ecological principles such as carrying capacity, disturbance and succession and environmental conditions such as physical geography, pedology and hydrology with the aim of balancing the needs of wildlife with the needs of people.

Most wildlife biologists are concerned with the preservation and improvement of habitats although re- wilding is increasingly being used. Techniques can include reforestation, pest control,nitrification and denitrification, irrigation, coppicing and hedge laying.

Game keeping is the management or control of wildlife for the wellbeing of game and may include killing other animals which share the same niche or predators to maintain a high population of the more profitable species, such as pheasants introduced into woodland. In his 1933 book *Game Management*, Aldo Leopold, one of the pioneers of wildlife management as a science, defined it as "the art of making land produce sustained annual crops of wild game for recreational use".

Three common ideas are present in every definition of wildlife management, including:

1. Efforts directed toward wild animal populations,
2. Relationship of habitat to those wild animal populations, and
3. Manipulations of habitats or populations that are done to meet some specified human goal.

There are two general types of wildlife management:

**i. Manipulative Management:**

Refers to acts on a population, either changing its numbers by direct means or influencing numbers by the indirect means of altering food supply, habitat, density of predators, or prevalence of disease. This is appropriate when a population is to be harvested, or when it slides to an unacceptably low density or increases to an unacceptably high level. Such densities are inevitably the subjective view of the land owner, and may be disputed by animal welfare interests.

**ii. Custodial Management:**

Is preventive or protective. The aim is to minimize external influences on the population and its habitat. It is appropriate in a national park where one of the stated goals is to

protect ecological processes. It is also appropriate for conservation of a threatened species where the threat is of external origin rather than being intrinsic to the system. Feeding of animals by visitors is generally discouraged.

### 5.3.1 Why Manage for Wildlife?

? *Dear learners; why do we need to manage Wildlife?* (Use the space below for your answer)

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Landowners can obtain both tangible and intangible benefits from managing wildlife. Tangible benefits primarily accrue from leasing rights for hunting and other forms of outdoor recreation involving wildlife. Fees collected from these activities can provide income to pay property taxes and other management costs. The provision of various services (e.g. guides, dogs, lodging, meals, etc.) associated with hunting can also provide another source of income. Although public demand for wildlife-related outdoor recreation (e.g., hiking, camping, bird watching, canoeing, etc.) has not yet reached the point of providing significant income for private landowners in South Carolina, the potential exists and will increase in the future.

Intangible benefits from wildlife management can include the excitement derived from observing wildlife, the satisfaction of providing desirable habitat for these species and the pride from receiving recognition for conservation efforts.

## 5.4 Preservation, Conservation and Management

? *Dear learners; what is your understanding about preservation, conservation and management?* (Use the space below for your answer)

Let's now examine the differences between management, conservation, and preservation, because many people mistakenly confuse wildlife management with wildlife preservation.

- **Conservation:** is an effort to maintain and use natural resources wisely in an attempt to ensure that those resources will be available for future generations. Wise use of resources could vary from actively managing white-tailed deer populations by hunting to protecting and preserving spotted owl populations and habitat.

- **Preservation:** is a component or part of conservation in which natural systems are left alone without human disturbance or manipulation. Preservationists (people who believe in preservation) feel natural resources should be protected, unspoiled, and untouched by humans. The goal of preservation is often maintaining the integrity of the ecosystem as exemplified by nature preserves or wilderness areas.

- **Management:** is also a component of conservation that usually means controlling, directing, or manipulating wildlife populations and/or their habitats (active management strategy). Wildlife managers usually seek to:

    - Increase a population (by providing key habitat components such as food, shelter and water);
    - Decrease a population (by harvesting deer when they are damaging orchard trees or soybean crops); or

- Stabilize a population so that individuals can be removed on a continuing basis, making sure that enough individuals remain in the population to replace those that are removed (**sustained yield**).

**Summary**

Although a lot can be said, wildlife refers to all living organisms out of the direct control of man, including undomesticated or cultivated plants and animals or refers to non-domesticated animal species, but has come to include all plants, fungi, and other organisms that grow or live wild in an area without being introduced by humans.

Despite people can obtain both tangible and intangible benefits from managing wildlife, it is evident that the survival of wild life is being deteriorated with the elapse of time mainly due to climate change, unregulated hunting and poaching, habitat and environmental pollution, human population growth, habitat destruction, impact of introduced species, chains of extinction and so on.

As counter measures to the threats of the earth's wildlife, numerous preservation, conservation and management measures are being implemented.

**Check list**

Dear learner, now this chapter is over. Put ( ✓) mark in the box against each of the following points if you are sure of it and (×) mark if you are not sure of it. If you put (✓) mark for each case, do the activity followed by the check list and proceed to the next chapter. If there is any (× ) mark, please return back to that issue before proceeding to the next part of the course.

| I can: | | |
|---|---|---|
| 1 | Define Wildlife | ☐ |
| 2 | Mention problems of Wildlife | ☐ |
| 3 | Explain the methods of wildlife conservation and management | ☐ |
| 4 | Describe the need to manage wildlife resources | ☐ |
| 5 | Differentiate preservation from conservation and management | ☐ |

**Exercise 5:**

1. What does it mean by wildlife? Discuss the definition from different perspectives.
2. What are the major challenges of earth's wildlife?
3. Differentiate the concept of preservation from conservation and management.
4. How could people be benefited from managing wildlife?

# CHAPTER SIX

# 6. WATER RESOURCES

**Contents:**



**Objectives:**

✧ **After the completion of this chapter, learners will be able to:**

- Identify the importance of water for life on the earth's surface
- Explain the major causes of water stress in most parts of the world
- Identify the main causes of water pollution
- Elaborate major water resource management and conservation mechanisms

## 6.1 Characteristics and Major Uses of Water

Water is the most abundant and most important resources of life, covering about 71 percent of the earth's surface. Two common measures of human water use are **water withdrawal and water consumption**. Water withdrawal involves taking water from a ground or surface sources and transporting in to a place of use. Water consumption occurs when water that has been withdrawn is not available for reuse in the area from which it is withdrawn. Generally water is important for:

- Water use for domestic, municipal, transportation and dilution of wastes
- Water resource use for food production, for generating hydroelectric power, recreation, fishing
- Water resource use for manufacturing and processing of natural resources as well as

Navigation

### 6.1.1 Sectorial Uses of Fresh Water

Uses of fresh water can be categorized as consumptive and non-consumptive (sometimes called "renewable"). A use of water is consumptive if that water is not immediately available for another use. Losses to sub-surface seepage and evaporation are considered consumptive, as is water incorporated into a product. Water that can be treated and returned as surface water, such as sewage, is generally considered non-consumptive if that water can be put to additional use.

- **Agricultural: -** It is estimated that 69% of worldwide water use is for irrigation, with 15-35% of irrigation withdrawals being unsustainable.In some areas of the world irrigation is necessary to grow any crop at all, in other areas it permits more profitable crops to be grown or enhances crop yield. Various irrigation methods involve different trade-offs between crop yield, water consumption and capital cost of equipment and structures. Irrigation methods such as furrow and overhead sprinkler irrigation are usually less expensive but are also typically less efficient, because much of the water evaporates, runs off or drains below the root zone. Other irrigation

methods considered to be more efficient include drip or trickle irrigation, surge irrigation, and some types of sprinkler systems where the sprinklers are operated near ground level. These types of systems, while more expensive, usually offer greater potential to minimize runoff, drainage and evaporation.

Aquaculture is a small but growing agricultural use of water. Freshwater commercial fisheries may also be considered as agricultural uses of water, but have generally been assigned a lower priority than irrigation. As global populations grow, and as demand for food increases in a world with a fixed water supply, there are efforts underway to learn how to produce more food with less water, through improvements in irrigation methods and technologies, agricultural water management, crop types, and water monitoring.

? *Dear learners; explain the importance of water for the industrial sector.*(Use the space below for your answer)

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- **Industrial: -** It is estimated that 22% of worldwide water use is industrial. Major industrial users include power plants, which use water for cooling or as a power source (i.e. hydroelectric plants), ore and oil refineries, which use water in chemical processes, and manufacturing plants, which use water as a solvent.The portion of industrial water usage that is consumptive varies widely, but as a whole is lower than agricultural use. Water is used in power generation. Hydroelectric power comes from water driving a water turbine connected to a generator. Hydroelectricity is a low-cost, non-polluting, renewable energy source. Water is also used in many industrial processes and machines, such as the steam turbine and heat exchanger, in addition to its use as a chemical solvent. Discharge of untreated water from industrial uses is pollution. Pollution includes discharged solutes (chemical pollution) and discharged coolant water (thermal pollution). Industry requires

pure water for many applications and utilizes a variety of purification techniques both in water supply and discharge.

？*Can you mention some of the uses of water at the household level?*(Use the space below for your answer)

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- **Household: -** It is estimated that 8% of worldwide water use is for household purposes. These include drinking water, bathing, cooking, sanitation, and gardening. Drinking water is water that is of sufficiently high quality so that it can be consumed or used without risk of immediate or long term harm. Such water is commonly called potable water.

- **Recreation: -** Recreational water use is usually a very small but growing percentage of total water use. Recreational water use is mostly tied to reservoirs. If a reservoir is kept fuller than it would otherwise be for recreation, then the water retained could be categorized as recreational usage. Release of water from a few reservoirs is also timed to enhance whitewater boating, which also could be considered a recreational usage. Other examples are anglers, water skiers, nature enthusiasts and swimmers.Recreational usage is usually non-consumptive. Recreational usage may reduce the availability of water for other users at specific times and places. For example, water retained in a reservoir to allow boating in the late summer is not available to farmers during the spring planting season. Water released for whitewater rafting may not be available for hydroelectric generation during the time of peak electrical demand.

- **Environmental: -** Explicit environmental water use is also a very small but growing percentage of total water use. Environmental water usage includes artificial wetlands, artificial lakes intended to create wildlife habitat, fish ladders, and water releases from reservoirs timed to help fish spawn. Like recreational usage, environmental usage is non-consumptive but may

reduce the availability of water for other users at specific times and places. For example, water release from a reservoir to help fish spawn may not be available to farms upstream.

## 6.2Problems of Water Pollution

Water pollution occurs when wastes (like human and animals waste, chemicals, metals oils) are dumped to rivers, lakes, oceans and other bodies of water sources. The major sources of water pollution can be classified as **point and non-point sources**.

- **Point sources:** include discharge pollutant at specific location through pipes, ditches or sewers in to bodies of surface water like factories, sewage treatment plants, electric power plants, coal mines etc.
- **Non point sources**: are big land areas that discharge pollutant in to surface and underground over large area. This include runoff in to surface water and seepage in to ground water from croplands, livestock feedlots, logged forests, urban and suburban lands, septic tanks, etc. The most common types of water pollution are:-

I. **Disease-causing agents**: - include bacteria, viruses, protozoa, and parasitic worms that enter water from domestic sewage and animal waste.

II. **Oxygen –demanding wastes**: - include organic wastes, which when decomposed by oxygen consuming bacteria, can deplete water of dissolved oxygen gas.

III. **Water-soluble inorganic chemicals**: - high levels of dissolved solid chemicals like acid, salts, and compounds of toxic metals such as mercury, and lead can make water unfit to drink, harm fish and other aquatic life, depress crop yields, and accelerated corrosion of equipment that uses water.

IV. **Inorganic plant nutrients**: - water soluble nitrate and phosphate compounds that can cause excessive growth of algae and other aquatic plants, which then die and decay, depletes water of dissolved oxygen and kills fish.

V. **Organic chemicals**: - oil, gasoline, plastics, pesticides, cleaning solvents, detergents, and many other water soluble and insoluble chemicals threatened human health and harm aquatic life.

VI. **Sediments or suspended matter**: - insoluble practices of soil, silt and other solid inorganic and organic materials can reduce the ability of some organisms to find food, reduces photosynthesis by aquatic plants, disrupts aquatic food webs; fills lakes, harbors, stream channels and reservoirs.

VII. **Radioactive substances**: - radio-stops that are water soluble or capable of being biologically amplified in higher concentrations as they pass through food chains and webs. Ionizing radiations from such isotopes can cause birth defects, cancer and genetic damage.

VIII. **Heat**: - could be caused by excessive inputs of heated water used to cool electric power plants. The resulting increases in water temperatures lower dissolves oxygen content and make aquatic organisms more vulnerable to diseases, parasites and toxic chemicals.

Water pollution is brought about by the discharge in to water of substances that cause unfavorable changes in its chemical or physical nature or in the quality and quantity of the organisms living in the water. The four major contributors to water pollution are agriculture, industry, mining and municipalities & residences.

？*Dear learners; explain how agricultural activity, industrialization and waste disposal frommunicipalities and residences pollute water.* (Use the space below for your answer)

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**1. Agriculture Sources of Water Pollution**: on a worldwide basis, agriculture probably contributes more to water pollution than does any other single activity. Agriculture runoff carries three main types of pollutants, namely fertilizers, biocides and animal wastes.

- **Fertilizers**: agriculture is a chief contributor of excess nutrients to water bodies. Pollution occurs when nitrates and phosphates that have been used in fertilizers and that present in animal manure drain in to streams and rivers, eventually accumulating in ponds, lakes and estuaries.

- **Biocides**: the herbicides and pesticides used in agriculture are another source of the chemical pollution of water bodies. Runoff from farms where such biocides have been applied contaminates both ground and surface waters.

- **Animal wastes**: animal wastes is a problem both in feedlots, where animals are crowded together at maximum densities to be fattened before slaughter, and on the factory-like farms where beef, hog, and poultry production is increasingly concentrated.

**2. Industry**: many industries discharge organic and inorganic wastes in to bodies of water. Drinking, bathing in or cooking with the polluted water can cause liver cancer, nerve damage, circulatory problems, and skin lesions. The petroleum industry is a significant contributor to the chemical pollution of water (oil spills). Oceans are becoming increasingly contaminated by oils. Acid precipitation (usually called acid rain), a by-product of emissions from factories, power plants and automobiles, has affected the water quality and ecology of thousands of lakes and streams in the world. Many industrial processes, as well as electric power production require the use of water as a coolant. Thermal pollution occurs when water that has been heated is returned to the environment and has adverse effects on the plants and animals in the water body. In addition, the higher the temperature of the water, the less oxygen it contains, which means that only lower-order plants and animals can survive.

**3. Mining**: surface mining for coal, copper, gold, uranium and other substances contributes to contamination of the water supply through the wastes it generates. Rain water reacts with the wastes and dissolved minerals seep in to nearby water bodies; contaminating the water. In addition to altering the quality of the water, the contaminants have secondary effects on soils, vegetation and animals.

**4. Municipalities and Residences**: a host of pollutants derives from the activities associated with urbanization. The use of detergents has increased the phosphorous content of rivers and salt (used for deicing roads) increases the chloride content of runoff. Water runoff from urban areas contains contaminants from garbage, animal dropping, litter, vehicle drippings and the like. Sewage can also be a major water pollutant depending on how well it is treated before being discharged. This is not simply an environmental concern; it directly affects human health; raw, untreated human waste contains viruses responsible for dysentery, polio, hepatitis, spinal meningitis and other diseases.

## 6.3 Water Resource Management and Conservation

Although we can't increase the earth's supply of water, we can manage what we have better to reduce the impact and spread of water resource problems. Water management principle is either making the available water resource sustainable or depositing water in different water reservoirs and to decrease unnecessary loss and waste. One way to manage water resources is to increase the supply, mostly by building dams and reservoirs and diverting surface water. The other approach is to improve the efficiency of water use by decreasing unnecessary use and waste. Major methods for managing water resource are:

1. **Constructing Dams and Reservoirs**: - Rain water and water from melting snow that would otherwise be lost can be captured and stored in large water reservoirs like dams.

?*Explain the significances and drawbacks of dams as a water management system.* (Use the space below for your answer)

- **Advantage of Dams and Reservoirs**
  - Helps to increase the annual supply by collecting fresh surface water during wet periods
    and storing it for use during dry periods;
  - Reduces the danger of flooding in downstream area;
  - Provides a controllable supply of water for irrigating arid and semiarid lands;
  - Helps to generate electricity;
  - Used for outdoor recreation like swimming, boating, fishing.

- **Disadvantages of Dams and Reservoirs**
  - Expensive to build
  - Displaces people and destroy vast area of valuable agricultural land, wild life, and scenic natural beauty
  - Raises the water table (the higher water table often water logs the soil nearby land , decreasing its crop or forest productivity)
  - Evaporation also increases the salinity of reservoir water by leaving salts behind – decreasing its usefulness for irrigation.
  - Trap silt so it deprive downstream areas and estuaries of vital nutrients and decrease their productivity
  - Create favorable condition to reproduce mosquitoes
  - Faulty construction, earthquakes, sabotage, war can cause dams to fail - taking a terrible toll in lives and property.

2. **Water Diversion Project**: - diverting of water from water rich region to mostly arid and semiarid regions. Even though it provides enough water for irrigation, domestic and industrial uses, it can cause different types of ecological disasters like loss of aquatic life, disappearance of lakes, and depletion of ground water.

3. **Trapping Ground Water**: - Even though it helps of satisfy shortage of water, unwise may cause problems like aquifer depletion (occurs when ground water is withdrawn faster than its recharge by percolation); subsidence (sinking of land when ground water is withdrawn excessively); intrusion of salt water in to aquifer; ground water contamination from agricultural and industrial activities.

4. **Desalinization**: - removing of dissolved salts from ocean water or slightly salty ground water through **distillation** and **reverse osmosis**. Distillation involves heating salt water until evaporates and condenses as fresh water, leaving salts behind in solid form. In reverse osmosis, high pressure is used to force salt water through a thin membrane whose pores allow water molecules but not dissolved salt to pass through. The basic problem in desalination methods is that they use large amounts of energy and therefore are expensive.

5. **Encouraging the Public to Reduce Unnecessary Water Waste and Use: -** manufacturing processes can either use recycled water or can be redesigned to use and waste less water. Leaks in pipes, water mains, toilets, bath tubs and faucets waste an estimated 20% to 30% of water withdrawn for public supplies.
6. **Decreasing Evaporation of Irrigation Water**: - it can be done by preventing seepage (by placing plastic, concert tile liners in irrigation canal), by mulching etc.

Table 3: Methods for Managing Water Resources (summary)

| Increase the supply | Reduce unnecessary loss and waste |
|---|---|

| | |
|---|---|
| Build dams and reservoirs<br>Divert water from one region to another<br>Tap more ground water<br>Convert salt water to fresh water (desalinization)<br>Tow freshwater icebergs from to water-sh coastal regions<br>Seed clouds to increase precipitation | Decrease evaporation of irrigation water Redes<br>mining and industrial processes to use less wat<br>Encourage the public to reduce unnecessary wa waste and use<br>Increase the price of water to encourage wa conservation<br>Purify polluted water for reuse |

**Summary**

Water, covering about 71 percent of the earth's surface, is the most abundant and most important resources of life. Generally water is important for domestic, municipal, transportation and dilution of wastes; for food production, for generating hydroelectric power, recreation, fishing; and for manufacturing and processing of natural resources as well as navigation. The concept of water stress applies to situations where there is not enough water for all uses, whether agricultural, industrial or domestic which is a cumulative result of population growth, climate change; rapid urbanization, expansion of business activity and depletion of aquifers.

Water pollution occurs when wastes (like human and animals waste, chemicals, metals oils) are dumped to rivers, lakes, oceans and other bodies of water sources either from discharge pollutant at specific location through pipes, ditches or sewers in to bodies of surface water like factories, sewage treatment plants, electric power plants, coal mines etc. called point sources or discharge pollutant in to surface and underground over large area that include runoff in to surface water and seepage in to ground water from croplands, livestock feedlots, logged forests, urban and suburban lands, septic tanks, etc. called non-point sources. Water pollution is brought about by the discharge in to water of substances that cause unfavorable changes in its chemical or physical nature or in the quality and quantity of the organisms living in the water. The four major contributors to water pollution are agriculture, industry, mining and municipalities & residences. One way to manage water resources is to increase the supply, mostly by building dams and reservoirs and diverting surface water. The other approach is to improve the efficiency of water use by decreasing unnecessary use and waste mainly by decreasing evaporation of irrigation water, redesign mining and industrial processes to use less water, encouraging the public to reduce unnecessary water waste and use, and Purifying polluted water for reuse.

**Check list**

Dear learner, now this chapter is over. Put (✓ ) mark in the box against each of the following points if you are sure of it and (✖) mark if you are not sure of it. If you put (✓ ) mark for each case, do the activity followed by the check list and proceed to the next chapter. If there is any (✖ ) mark, please return back to that issue before proceeding to the next part of the course.

I can:

| | | |
|---|---|---|
| 1 | Mention the significance of water for agriculture, household, Municipalities, industry and recreation | ☐ |
| 2 | Identify the major sources of fresh water | ☐ |
| 3 | Explain the causes of worldwide water stress | ☐ |
| 4 | Identify the differences between point and non-point sources of water Pollution | ☐ |
| 5 | List down the common types of water polluting agents | ☐ |
| 6 | Explain the impacts of agricultural activity, industry, mining, Municipalities and residences on water resources | ☐ |
| 7 | Discuss the main water resource management and conservation techniques | ☐ |

**Exercise 6:**

1. What is the basic difference between point and non-point sources of water pollution?
2. What are the major causes and sources of water pollution?
3. Explain the concept of water pollution.
4. Differentiate water withdrawal from water consumption.
5. What does it mean by non-consumptive water?

# CHAPTER SEVEN

# 7. MINERAL RESOURCES

**Contents:**



**Objectives:**

✧ **Up on the completion of this chapter, learners will be able to:**

- Define Minerals
- Explain how minerals are formed
- Distinguish between mineral resources and reserves
- Identify the properties of minerals
- Explain mineral resource classification
- State the importance of mineral
- Describe measures which are helpful to conserve mineral resources.

## 7.1 Introduction

Mineral resources are valuable asset of the country, it is the material basis for the national economic and social development, and it is also an important basis of the production development and the protection for people's living standard. The using quality of mineral resource will directly relate to the sustainable development of human society. With the development of society, progress of science and technology as well as the world's population growth, the consumption speed of mineral resources has become faster and faster, while mineral resources prospecting has become increasingly difficult because of the improvement of the degree of geological work. In order to protect mineral resources and environment, we must be to maximize the protection and comprehensive utilize of mineral resources, to strengthen the management of mineral resources.

### 7.1.1 Definition of Minerals

?*Dear learners; what does the term mineral mean*? (Use the space below for your answer)

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A mineral is a naturally occurring, homogeneous inorganic solid substance having a definite chemical composition and characteristic crystalline structure, color, and hardness. Minerals are made up of elements, which are substances that cannot be broken down in to simpler substances by ordinary chemical means. Most minerals are combinations of two or more elements joining to form a chemically stable compound, but some are entirely made of one element. E.g. Diamond and Graphite. Elements have a smallest part known as an atom. Each atom has a central region called the nucleus, containing very dense positively charged protons and equally dense neutral particles called neutrons. Orbiting the nucleus are negatively charged particles known as electrons. All atoms have the same number of electrons as protons.

Every atom is an electrically neutral particle as the positive charge of protons is exactly balanced by the negative charge of electrons. Chemical bonds develop when the atoms of two or more elements join to form a compound. When an atom combines chemically, it either loses, gains or shares electrons with other atom. An atom that loses electrons become positively charged because it has more protons than electrons, while an atom that gains electrons become negatively charged as it has more electrons than protons. Atoms that have an electrical charge because of loss or gain of electrons are called ions. Oppositely charged ions attract one another and produce a neutral chemical compound or mineral. The new compound is different from the elements making up it.

## 7.2Major Rock-Forming Minerals

？*What are the major rock forming minerals?* (Use the space below for your answer)

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Although about 3500 minerals are known to exist in the Earth's crust, only a small numberbetween 50 and 100are important because they are common or valuable.

The rock-forming minerals make up the bulk of most rocks in the Earth's crust. They are important to geologists simply because they are the most common minerals. They are olivine, pyroxene, amphibole, mica, the clay minerals, feldspar, quartz, calcite, and dolomite. The first six minerals in this list are actually mineral "groups," in which each group contains several varieties with very similar chemical compositions, crystalline structures, and appearances.

- **ACCESSORY MINERALS**

**Accessory minerals** are minerals that are common but usually are found only in small amounts. Chlorite, garnet, hematite, limonite, magnetite, and pyrite are common accessory minerals.

Figure 4: Pyrite is a common accessory mineral. (*American Museum of Natural History*)

- **GEMS**

A **gem** is a mineral that is prized primarily for its beauty, although some gems, like diamonds, are also used industrially. Depending on its value, a gem can be either precious or semiprecious. Precious gems include diamond, emerald, ruby, and sapphire. Several varieties of quartz, including amethyst, agate, jasper, and tiger's eye, are semiprecious gems. Garnet, olivine, topaz, turquoise, and many other minerals sometimes occur as aesthetically pleasing semiprecious gems.

Figure 5: Sapphire is one of the most costly precious gems. (*Smithsonian Institution*)

- **ORE MINERALS**

**Ore minerals** are minerals from which metals or other elements can be profitably recovered. A few, such as native gold and native silver, are composed of a single element. However, most metals are chemically bonded to anions. Copper, lead, and zinc are commonly bonded to sulfur to form the important ore minerals chalcopyrite, and sphalerite.

Figure 6: Galena is the most important ore of lead and commonly contains silver (*Ward's Natural Science Establishment .inc*)

- **INDUSTRIAL MINERALS**

Several minerals are industrially important, although they are not considered ore because they are mined for purposes other than the extraction of metals. Halite is mined for table salt, and gypsum is mined as the raw material for plaster and sheetrock. Apatite and other phosphorus minerals are sources of the phosphate fertilizers crucial to modern agriculture. Many limestone are made up of nearly pure calcite and are mined as the raw material of cement.

## 7.3Properties of Minerals

The chemical compositions of a mineral are difficult to determine without the aid of sophisticated tests and apparatus. The most easily recognized properties of a mineral are those of its physical properties. The physical properties that are helpful in identification of minerals are:

a. **Crystal form** – is the characteristic shape of a mineral and the manner in which aggregates of crystals grow. If a crystal grows freely, it develops a characteristic shape controlled by the arrangement of its atoms. Some minerals occur in more than one habit. For example, quartz with a prismatic (pencilshaped) habit, and massive quartz. When crystal growth is obstructed by other crystals, a mineral cannot develop its characteristic habit.

b. **Color** –is the most obvious property of a mineral, but it is commonly unreliable for identification. Color would be a reliable identification tool if all minerals were pure and had perfect crystal structures. However, both small amounts of chemical impurities and imperfections in crystal structure can dramatically alter color. For example, corundum ($Al_2O_3$) is normally a cloudy, translucent, brown or blue mineral. Addition of a small amount of chromium can convert corundum to the beautiful, clear, red gem known as ruby. A small quantity of iron or titanium turns corundum into the striking blue gem called sapphire.

c. **Streak** –is the color of a fine powder of a mineral. It is observed by rubbing the mineral across a piece of unglazed porcelain known as a streak plate. Many minerals leave a streak of powder with a diagnostic color on the plate. Streak is commonly more reliable than the color of the mineral itself for identification.

d. **Luster** –is the manner in which a mineral reflects light. A mineral with a metallic look, irrespective of color, has a metallic luster. The luster of nonmetallic minerals is usually described by self-explanatory words such as glassy, pearly, earthy, and resinous.

**e. Hardness** – is the resistance of a mineral to scratching. It is easily measured and is a fundamental property of each mineral because it is controlled by bond strength between the atoms in the mineral. Geologists commonly gauge hardness by attempting to scratch a mineral with a knife or other object of known hardness. If the blade scratches the mineral, the mineral is softer than the knife. If the knife cannot scratch the mineral, the mineral is harder.

To measure hardness more accurately, geologists use a scale based on ten minerals, numbered 1 through 10. Each mineral is harder than those with lower numbers on the scale, so 10 (diamond) is the hardest and 1 (talc) is the softest. The scale is known as the **Mohs hardness scale** after F. Mohs, the Austrian mineralogist who developed it in the early nineteenth century.

The Mohs hardness scale shows, for example, that a mineral scratched by quartz but not by orthoclase has a hardness between 6 and 7. Because the minerals of the Mohs scale are not always handy, it is useful to know the hardness values of common materials. A fingernail has a hardness of slightly more than 2, a copper penny about 3, a pocketknife blade slightly more than 5, window glass about 5.5, and a steel file about 6.5. If you practice with a knife and the minerals of the Mohs scale, you can develop a "feel" for minerals with hardnesses of 5 and under by how easily the blade scratches them.

**f. Cleavage** – is the tendency of some minerals to break along flat surfaces. The surfaces are planes of weak bonds in the crystal. Some minerals, such as mica and graphite, have one set of parallel cleavage planes. Others have two, three, or even four different sets. Some minerals, like the micas, have excellent cleavage. You can peel sheet after sheet from a mica crystal as if you were peeling layers from an onion. Others have poor cleavage. Many minerals have no cleavage at all because they have no planes of weak bonds. The number of cleavage planes, the quality of cleavage, and the angles between cleavage planes all help in mineral identification.

A flat surface created by cleavage and a crystal face can appear identical because both are flat, smooth surfaces. However, a cleavage surface is duplicated when a crystal is broken,

whereas a crystal face is not. So if you are in doubt, break the sample with a hammer—unless, of course, you want to save it.

**g. Fracture** – is the pattern in which a mineral breaks other than along planes of cleavage. Many minerals fracture into characteristic shapes. Conchoidal fracture creates smooth, curved surfaces. It is characteristic of quartz and olivine. Glass, although not a mineral because it has no crystalline structure, also typically fractures in a conchoidal pattern. Some minerals break into splintery or fibrous fragments. Most fracture into irregular shapes.

**h. Specific gravity** is the weight of a substance relative to that of an equal volume of water. If a mineral weighs 2.5 times as much as an equal volume of water, its specific gravity is 2.5. You can estimate a mineral's specific gravity simply by hefting a sample in your hand. If you practice with known minerals, you can develop a feel for specific gravity. Most common minerals have specific gravities of about 2.7. Metals have much greater specific gravities; for example, gold has the highest specific gravity of all minerals, 19. Lead is 11.3, silver is 10.5, and copper is 8.9.

## 7.4Mineral Resource Classification

?Dear learners; how do you classify mineral resources? *(*Use the space below for your answer)

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Estimates of mineralization are first classified into one of two main categories, either Mineral Resources or Mineral Reserves, depending on the different degrees of technical and economic evaluation. Those two categories of classification are further subdivided according to different levels of geological knowledge and confidence. Mineral Resources can be classified as Inferred, Indicated, or Measured; and Mineral Reserves as Probable or Proved.

### 7.4.1 Mineral Resources

A Mineral Resource is a concentration or occurrence of material of intrinsic economic interest in or on the Earth's crust in such form and quantity that there are reasonable prospects for eventual economic extraction. Those portions of a mineralized deposit which do not have reasonable prospects for eventual economic extraction must not be included in a Mineral Resource. The geological characteristics of a Mineral Resource (such as location, quantity, grade, and continuity) are known, estimated, or interpreted from specific geological evidence and knowledge. Mineral Resources are sub-divided, in order of increasing geological confidence, into Inferred, Indicated and Measured categories.

**A. Inferred Mineral Resources**

An Inferred Mineral Resource is that part of a Mineral Resource for which tonnage, grade and mineral content can be estimated with a low level of confidence. It is inferred from geological evidence and assumed but not verified geological and/or grade continuity. It is based on information gathered through appropriate techniques from locations such as outcrops, trenches, pits, workings and drill holes which may be limited or of uncertain quality and reliability. Due to the uncertainty attached to Inferred Mineral Resources, it cannot be assumed that all or a portion of such resource will be upgraded to an Indicated or Measured Mineral Resource as a result of more exploration.

**B. Indicated Mineral Resources**

An Indicated Mineral Resource is that part of a Mineral Resource for which tonnage, densities, shape, physical characteristics, grade and mineral content can be estimated with a reasonable level of confidence. It is based on exploration, sampling and testing information gathered through appropriate techniques from locations such as outcrops, trenches, pits, workings and drill holes. The locations are too widely or inappropriately spaced to confirm geological and/or grade continuity but are spaced closely enough for continuity to be assumed. This category has a confidence level higher than Inferred Mineral Resources but a lower confidence level than Measured Mineral Resources.

**C. Measured Mineral Resources**

A Measured Mineral Resource is that part of a Mineral Resource for which tonnage, densities, shape, physical characteristics, grade and mineral content can be estimated with a high level of confidence. It is based on detailed and reliable exploration, sampling and testing information gathered through appropriate techniques from locations such as outcrops, trenches, pits, workings and drill holes. The locations are spaced closely enough to confirm geological and grade continuity.

### 7.4.2 Mineral Reserves

A Mineral Reserve is the economically mineable part of a Measured and/or Indicated Mineral Resource. It includes diluting materials and allowances for losses, which may occur when the material is mined. Appropriate assessments and studies have been carried out, and include consideration of and modification by realistically assumed mining, metallurgical, economic, marketing, legal, environmental, social and governmental factors.

These assessments demonstrate at the time of reporting that extraction could reasonably be justified. Mineral Reserves are sub-divided in order of increasing confidence into Probable Reserves and Proved Reserves. Probable Mineral Reserves and Proved Mineral Reserves have the same definition as discussed with respect to Mineral Reserves except that they are further refined in that:

**A. Probable Mineral Reserves**: are the economically mineable part of Indicated Mineral Resource and in some circumstances, Measured Mineral Resources; and

**B. Proved Mineral Reserves**: are the economically mineable parts of a Measured Mineral Resource. A Probable Mineral Reserve has a lower level of confidence than a Proved Mineral Reserve. The choice of the appropriate category of Mineral Reserve is determined primarily by the relevant level of confidence of the Mineral Resource.

In general, while Mineral Resources can be estimated based on predominantly geoscientific information, Mineral Reserves are dependent on the consideration of modifying factors such as

mining, metallurgical, economic, marketing, legal, environmental, social, and governmental factors. Such Mineral Reserve estimation will, therefore, require the knowledge of a variety of disciplines. Mineral Reserves can only be estimated based on Indicated or Measured Resources.

## 7.5 Mineral Resources Uses and Conservation

？*How can you preserve mineral at your locality?(*Use the space below for your answer)

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The minerals occurs naturally in the earth's crust, however, their distribution is not even. Minerals essential to our industrialized society and daily life are non-renewable resources. Due to the increase in industrialization, the consumption of minerals has increased tremendously all over the world. The minerals now is short supply will probably be exhausted within next 20 to100 years. Even the minerals which are relatively plentiful will become extremely expensive because of the depletion of large, rich and easily accessible deposits of these metals. Extraction processing and disposal of minerals have negative effects on environment. Mining not only disturbs and damages the land, but also pollutes the soil, water and air. The land that has been destroyed due to mining is known as derelict land or mine spoil. Such derelicts land can be reclaimed or restored to a semi-natural condition by re- vegetation to prevent further degradation, and to make the land productive for other purposes.

### 7.5.1 Objectives of Conservation of Mineral Resources

The overall objectives in conservation of mineral resources are:-

- To encourage and support use of the lower quality minerals, where appropriate, in preference of higher quality primary aggregate.

- To restrict non-mineral development this would hinder in the working of existing mineral commitments or identified in the areas for future mineral extraction.
- To support the prior extraction of minerals which would otherwise to be sterilized by non-mineral development to support the re-use and recycling of the minerals and their products.

### 7.5.2 Conservation of High Quality Mineral Resources:

Following are some of the strategies that can be followed for the conservation of high quality mineral resources:

- Use of alternate sources of energy like solar energy, hydroelectric energy etc.
- Walking on a path that leads to sustainable development.
- Using the mineral resources with a greater efficiency.
- Use of renewable sources of energy.
- Avoid over-exploitation of the mineral resources.
- Use of biogas as a fuel for cooking instead of the non-renewable sources of energy.
- Re-use and recycle the minerals and their products. In recycling, used and discarded items are collected, re-melted and reprocessed into new products, e.g. gold, lead, nickel, steel, copper, aluminum, silver, zinc, etc. However, minerals in other products are lost through normal use, such as paints containing lead, zinc or chromium. During reuse, used products are collected and used over and over again, e.g. reuse of glass bottles. The benefits of reuse are greater than those of recycling. All products however may not be reused. Recycling and reusing not only renew the mineral resources, but also helps in saving unspoiled land from the distribution of mining, reducing the amount of solid waste that must be disposed, and reducing energy consumption and pollution.

In general, securing the effective and the efficient use of minerals in accordance with sustainability principles can only be achieved if all those involved in producing and using minerals and their products will make a commitment to ensuring that development becomes more sustainable.

**Summary**

Each mineral consists of chemical elements bonded together in definite proportions, so that its chemical composition can be given as a chemical formula. The crystalline structure of a mineral is the orderly, periodically repeated arrangement of its atoms. A unit cell is a small structural and compositional module that repeats itself throughout a crystal. The shape of a crystal is determined by the shape and arrangement of its unit cells. Every mineral is distinguished from others by its chemical composition and crystal structure.

Most common minerals are easily recognized and identified visually. Identification is aided by observing a few physical properties, including crystal habit, cleavage, fracture, hardness, specific gravity, color, streak, and luster.

**Check list**

Dear learner, now this chapter is over. Put (✓ ) mark in the box against each of the following points if you are sure of it and (✖) mark if you are not sure of it. If you put (✓ ) mark for each case, do the activity followed by the check list and proceed to the next chapter. If there is any (✖ ) mark, please return back to that issue before proceeding to the next part of the course.

I can:

| | | |
|---|---|---|
| 1 | Define mineral | ☐ |
| 2 | Discuss the different characteristics of minerals | ☐ |
| 3 | Explain mineral resources and reserves | ☐ |
| 4 | Explain the different measures for mineral resource management | ☐ |

**Exercise 7:**

1. What is a gem?
2. What properties distinguish minerals from other substances?
3. Why do some minerals have cleavage and others do not?
4. Why is color often an unreliable property for mineralidentification?
5. Differentiate Probable Mineral Reserves from Proved Mineral Reserves

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