08

Environmental Biology

What is environment ? The environment is the complex of physical, chemical, and biotic factors that act upon an organism or an ecological community and ultimately determine its form and survival

What is environmental biology?

Definition: A scientific study of the origins, functions, relationships, interactions, and natural history of living populations, communities, species, and ecosystems in relation to dynamic environmental processes.

In other words, Environmental biology is the study of different biological components of the environment and its relationship is with each other and with the abiotic components.

Why learn Environmental Biology?

By learning of environmental biology will be able to understand the structure and the functions of the environment we live in. Specifically to:

- understand how biotic and abiotic components of the environment are linked and interact with each other,
- recognize organizational levels of the environment,
- learn about major processes of an ecosystem,
- recognize different components of terrestrial and aquatic ecology,
- understand how human activities are altering ecological systems and
- understand how natural changes in the environment (such as climate change, flooding, erosion etc) affect species and habitats.

Organizational levels of the environment

Several levels of organization are recognized by environmental biologists.

Levels of organization include the individual/ organism , population, community, ecosystem, and

biosphere.

- Individual/ Organism – The first level is an individual. An individual is any organism or living thing. An organism has its own characters in physiology, evolution and behavior in relation to environmental factors.
- Population –A Group of individuals of the same species, living in the same area and producing fertile offspring through interbreeding.
- Community – A collection of populations of different species living in the same area interacting with each other.
- Ecosystem – An ecosystem is a collection of communities as well as the abiotic factors with which they interact.
- Biosphere – includes the entire portion of Earth that is inhabited by life.

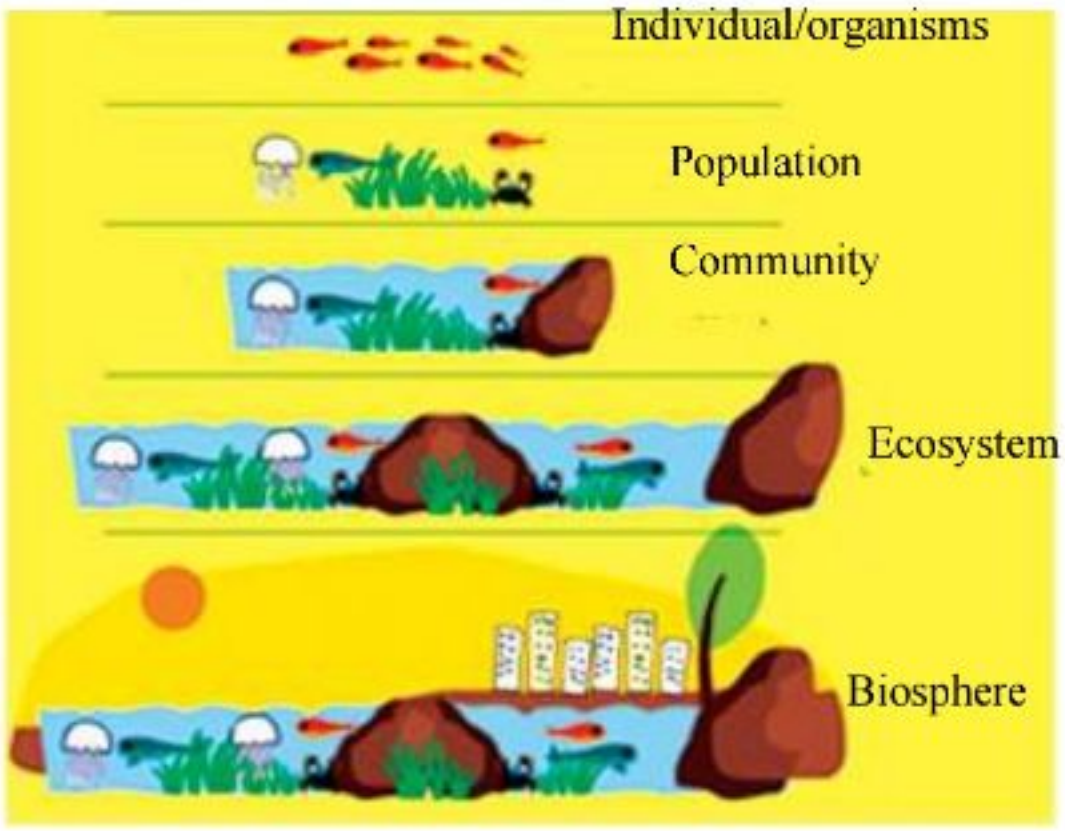


Figure 8.1: Organizational levels of an ecosystem

Major biotic and abiotic components in the environment

All Organisms live in a complex environment that includes several components which are categorized under two major groups:

- Abiotic components – The nonliving components (physical and chemical factors) of the environment such as water, air, light, temperature, nutrients, sunlight, soil. Abiotic resources are usually obtained from the lithosphere, atmosphere, and hydrosphere. Abiotic components limit the geographic range (distribution) and the abundance of species.
- Biotic components – the living components of the ecosystem include plants, animals, fungi, bacteria and protists etc.

Structure and function of ecosystems:

The concept of "Niche" and "habitat"

To understand how an ecosystem work, one should first look into the concepts of "niche" and "habitat."

Niche

A niche is the role that a particular organism plays in the ecosystem. Each organism plays a particular role in its ecosystem. In other words, a niche is how an organism "makes its living." .This involves how the organism gets its energy, which usually has to do with what an organism eats, and how the organism passes that energy through the ecosystem. An organism's niche also includes how the organism interacts with other organisms, its role in recycling nutrients, tolerance to environment conditions such as temperature, soil moisture, etc. Therefore niche of an organism describes what it needs to live and what it does in a particular ecosystem.

Habitat

The habitat is the physical area where a species lives. Many environment factors are used to describe a habitat. The average amount of sunlight received each day, the range of annual temperatures, and average yearly (annual) rainfall describe a habitat. These and other abiotic factors of the environment such as soil condition will determine the kind of traits an organism must have in order to survive there. A habitat should not be confused with an ecosystem: the habitat is the actual place of the ecosystem, whereas the ecosystem includes both the biotic and abiotic factors of the habitat.

Interactions between abiotic and biotic components of the environment

There are different types of interactions in an ecosystem. They are:

- Biotic-biotic interactions- e.g. competition, feeding relationships, symbiotic relationships between individuals and species.
- Biotic-abiotic interactions- e.g. water uptake of plants from soil
- Abiotic-abiotic interactions-e.g. chemical reactions occurring in the soil.

Feeding relationships within an ecosystem develop food webs and food chains through which energy is passed from one organism to another.

Energy transfer in an ecosystem

The main energy provider for the earth is the sun. Using sunlight the green plants produce their own energy and store in tissues. The source of energy required by all living organisms is the chemical energy of their food. Ultimately, chemical energy in any organism is obtained by the conversion of the radiant energy of sun which are stored in tissues of plants and animals.

Trophic level:

The producers and consumers in ecosystem can be arranged into several feeding groups, each known as trophic level (feeding level). In any ecosystem, producers represent the first trophic level, herbivores represent the second trophic level, primary carnivores represent the third trophic level and top carnivores represent other levels.

Food chain

A food chain is a linear sequence of organisms through which nutrients and energy pass from one trophic level to another trophic level of an ecosystem beginning with a primary producer. Let's look at the parts of a typical food chain, starting from the bottom (the producers) and moving upward.

primary producers

At the base of the food chain lie the primary producers. The **primary producers** are autotrophs and are most often photosynthetic organisms such as plants, algae, or cyanobacteria. These organisms convert light energy to chemical energy or in another words produce organic matter.

Primary production – is the amount of organic matter produced by autotrophs in a given area during a given period of time. (Unit: $gm^{-2}day^{-1}$ or $kg\ ha^{-1}year^{-1}$)

The organisms that consume (eat) the primary producers are called primary consumers. Primary consumers are usually herbivores (plant-eaters), though they may be algae eaters or bacteria eaters.

The organisms that consume the primary consumers are called secondary consumers. Secondary consumers are generally carnivores (meat-eaters).

The organisms that consume the secondary consumers are called tertiary consumers. These are carnivore-eating carnivores, such as Eagles or big fish species.

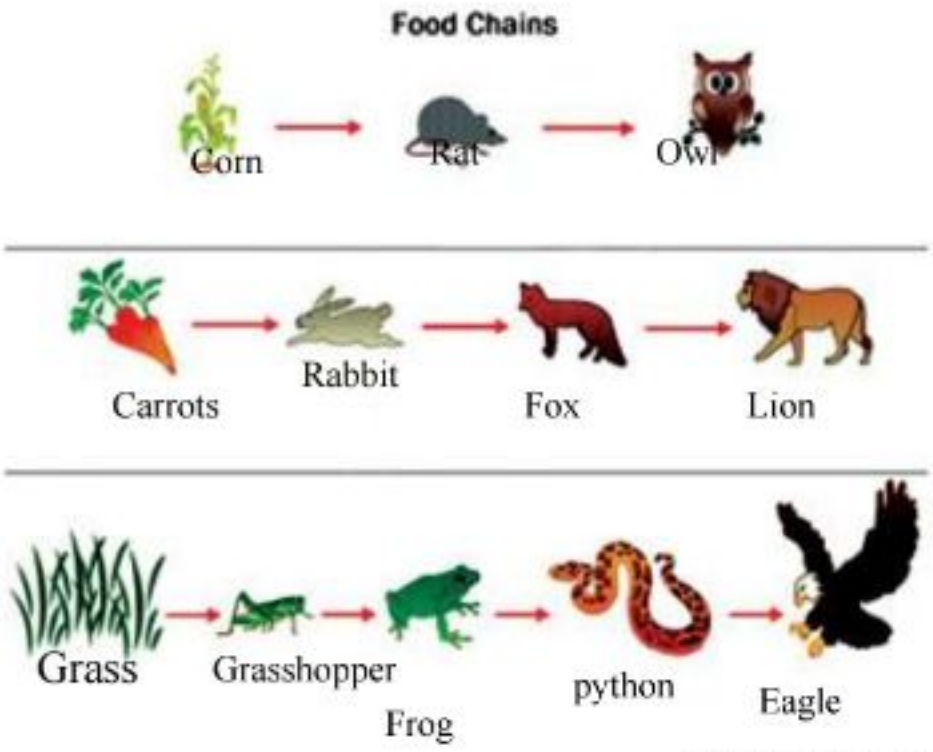


Figure 8.2: Food chains in a terrestrial ecosystem

Food web

In a natural ecosystem isolated food chains do not exists. The food chains are interconnected with each other to form food webs. The food web is an interconnected feeding relationships in an ecosystem. (Campbell, 10th edition, 2015)

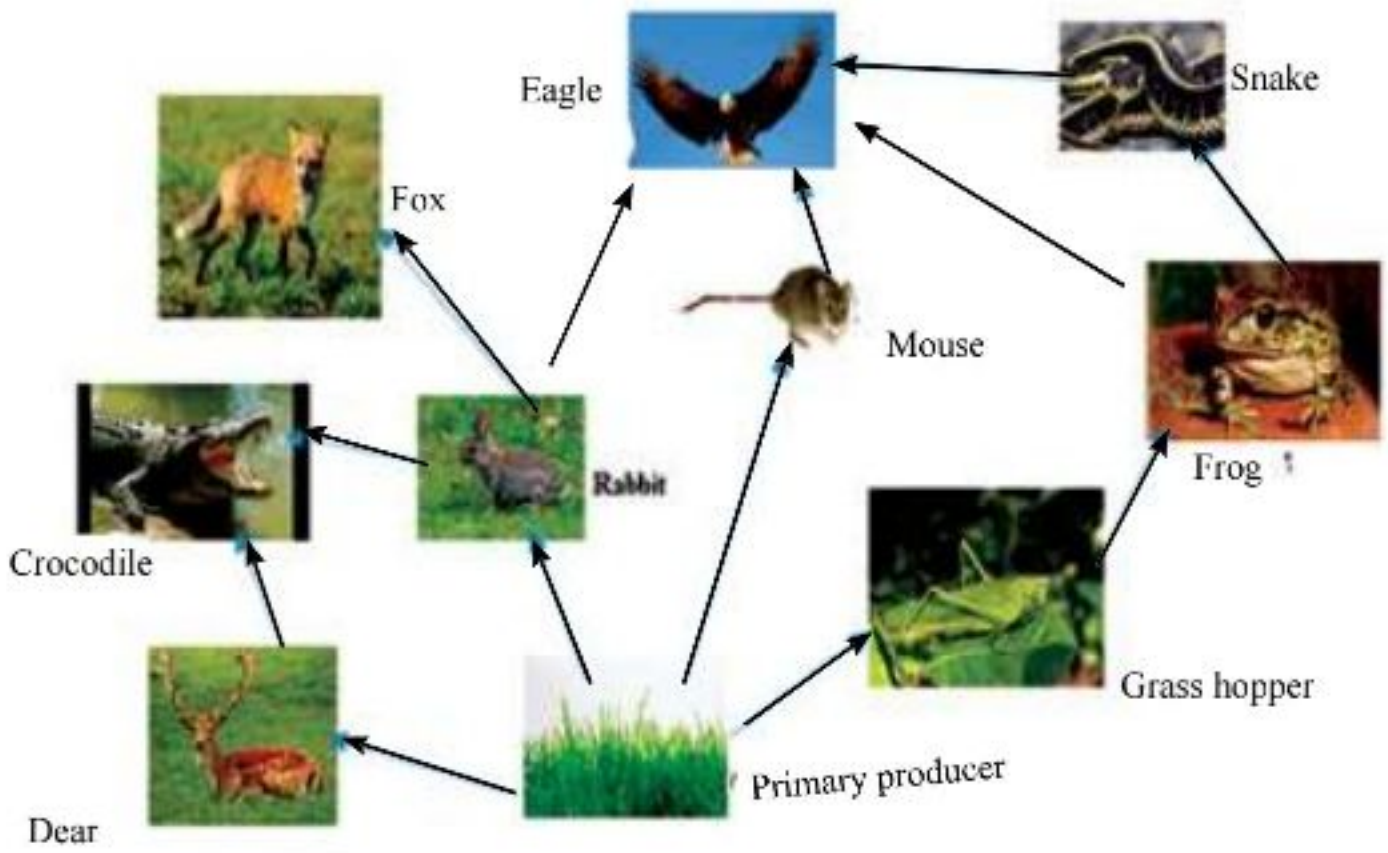


Figure 8.3 : Example for food web in a terrestrial ecosystem

Energy loss along food chains

The flow of energy along a food chain is always unidirectional. At each trophic level in the food chain, a considerable fraction (about 90 %) of the potential energy is lost as heat and respiration. As a result, organisms in each trophic level pass on lesser energy (about 10 %) to the next trophic level than they actually receive. This limits the number of trophic levels in any food chain to four or five. The most ecologically efficient food chain is the shortest one. Longer the food chain the lesser energy is available for top members. Because of this tapering off of available energy in the food chain a pyramid is formed that is known as an ecological pyramid. Shorter food chain has more energy available even at the highest trophic level than that of longer food chain.

Ecological pyramid:

The trophic structure of an ecosystem can be indicated by means of ecological pyramid. The higher the steps in the ecological pyramid the lower will be the number of individuals and the larger their size.

The concept of ecological pyramid was developed by Charles Elton; these pyramids are also known as Eltonian pyramids. The pyramids are a graphical representation which depicts the

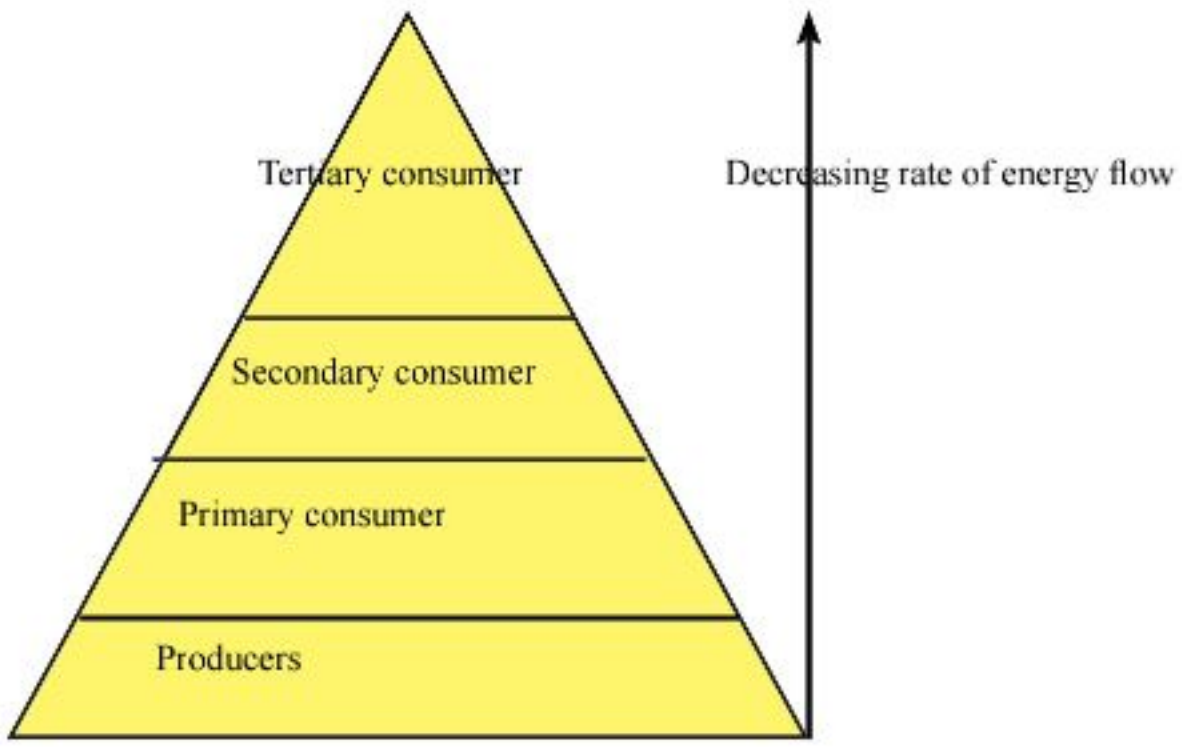
number of organisms, biomass and productivity at each trophic level. All ecological pyramids begin at the bottom with the primary producers and they proceed to various trophic levels such as herbivores consume plants, carnivores prey on herbivores and so on. The highest level is at the top of the food chain. There are three types of ecological pyramids:

- Pyramid of energy
- Pyramid of numbers
- Pyramid of biomass

Pyramid of Energy

Pyramid of energy represents the amount of energy at different trophic levels. The pyramid of energy or the energy pyramid describes the overall nature of the ecosystem. As there is considerable loss of energy during the flow of energy from organism to other, the energy pyramid always upright and vertical.

- This pyramid shows the flow of energy at different trophic levels.
- It depicts the energy is minimum as the highest trophic level and is maximum at the lowest trophic level.
- At each trophic level, there is successive loss of energy in the form of heat and respiration, etc.



Pyramid of Energy

Pyramid of Numbers

The pyramid of numbers depicts the relationship in terms of the number of producers, herbivores and the carnivores at their successive trophic levels. There is a decrease in the number of individuals from the lower to the higher trophic levels. The number pyramid varies from ecosystem to ecosystem. There are three types of pyramid of numbers:

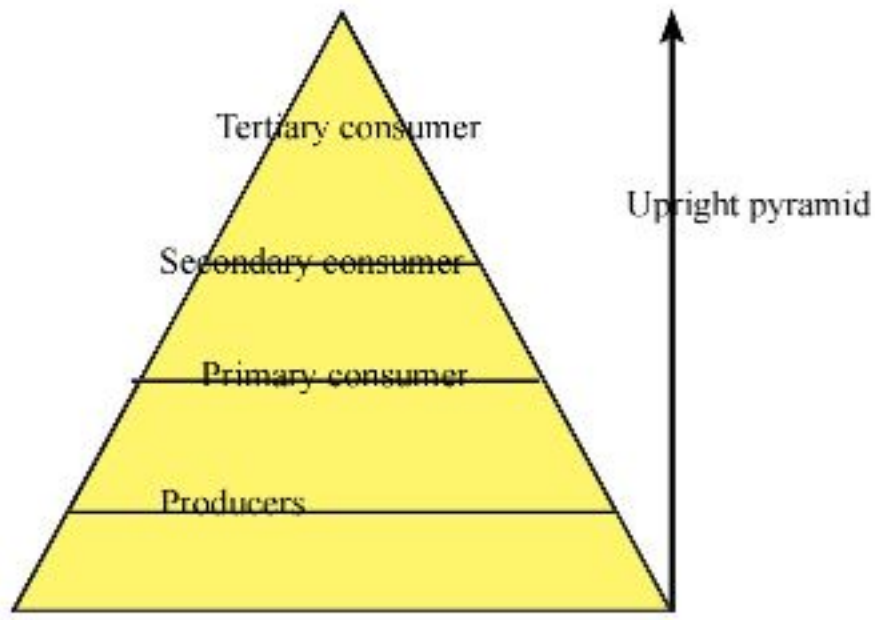
- Upright pyramid of number

  e.g. Producers ⟶ Herbivores ⟶ Carnivores

- Inverted pyramid of number.

  e.g. Host ⟶ Parasites

This type of pyramid number is found in the aquatic and grassland ecosystem, in these ecosystems there are numerous small autotrophs which support lesser herbivores which in turn support smaller number of carnivores and hence this pyramid is upright.



Pyramid of Number

Pyramid of Biomass

The pyramid of biomass is more fundamental. In this pyramid there is a gradual decrease in the biomass from the producers to the higher trophic levels. As the fresh weight of biomass contains a larger amount of water, dry weight of the biomass represents the amount of energy available in the form of organic matter of an organism.

There are two types of pyramid of biomass, they are:

- Upright pyramid of biomass and -This occurs when the larger net biomass of producers support a smaller biomass of consumers.

  Example: Forest ecosystem.
- Inverted pyramid of biomass.

  e.g. In some aquatic ecosystems phytoplanktons supports larger primary consumers.

8.4: Upright pyramid of Biomass

Cycling of materials in an ecosystem

The materials available for living organisms in the ecosystem is limited. Therefore these materials should be recycled. The material stock in the ecosystem is decreased when the organisms such as animals, plants, etc utilize them. Therefore when the organism is died, they are decomposed by decomposers. Thus those materials will be available for the organisms and absorb them into their body, assimilate and the excess will be removed as waste materials to the environment.

What is a biome?

A biome is a large geographical area which is classified based on the predominant vegetation adapted to that particular environment. The climate and geography of a region determines what type of biome can exist in that region. Each biome consists of many ecosystems whose communities have adapted to the small differences in climate, topography and soil conditions within the biome. Major terrestrial biomes include tropical forest, savanna, desert, chaparral, temperate grassland, temperate broad leaf forest, northern coniferous forest and tundra.

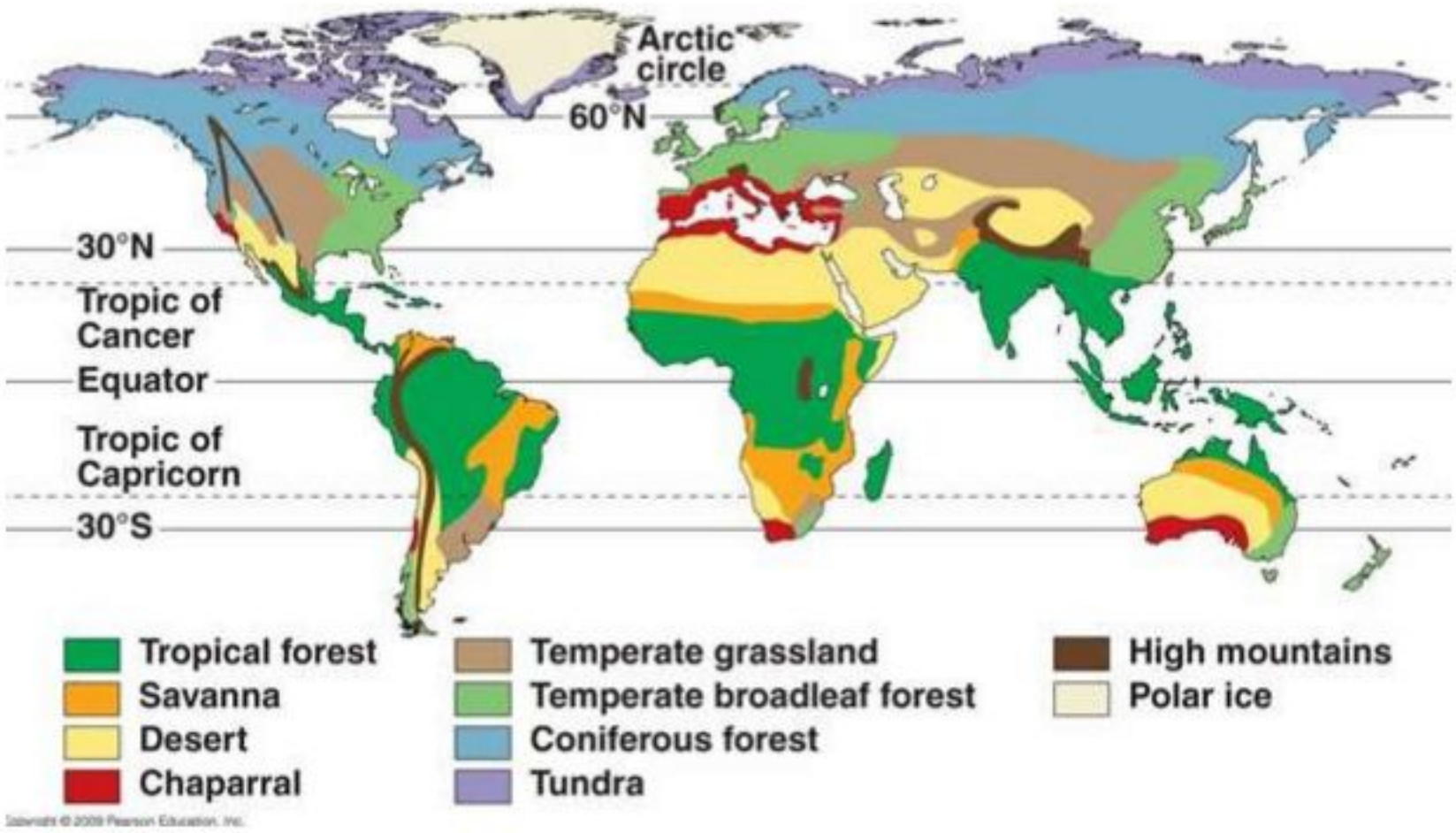


Figure 8.5: World distribution of different types of biomes

1. Tropical forests

This biome is distributed close to the equator and extends to the sub equatorial areas. Therefore both tropical rainforests and tropical dry forests are included.

The average annual rainfall in tropical rain forests is about 2000 -4000 mm and in tropical dry forests it is about 1500- 2000 mm. Seasonal rainfall with a dry season of 6-7 months is prominent in the dry forests and a fairly constant rainy season is prominent in the rainforests.

Tropical rainforests have an average temperature of 25 -29 °C, whereas in the tropical dry forests it may reach up to 33 °C.

In tropical rainforests an emergent layer, canopy and sub canopy layers are visible. These are followed by an understory layer which consists of shrubs, and large herbaceous plants. The forest floor consists of small herbaceous plants, mushrooms,and a thick layer of dried plant litter. Therefore the vegetation is arranged in several vertical layers and stratification is observed.

Evergreens are prominent in tropical rain forests whereas in dry forests leaves of deciduous species fall in the dry season. Epiphytes are common in this biome. However in dry forests they are less common. Shrubs with thorns as well as succulent plants often occur in dry forests. Tropical forests constitute the higher diversity of plants and animals out of all terrestrial biomes. It has many mammal species and 5-30 million species of arthropods some of which have not been fully described yet. Animals in this biome have adaptations to suit the environment.

Animals in the rainforests show year round activity. Camouflage is common among small animals. Large animals may have markings in their bodies . Birds often migrate to other regions during dry period.

Human involvement in agriculture and development related activities has led to destruction of these forests.

Figure 8.6: A tropical forest

2. Savanna

Savanna is spread close to the equator and subequatorial areas.

The average annual rainfall in this biome is around 300-500 mm. A prolonged dry season of approximately 8-9 months is prominent. The average temperature range is 24- 29 °C. However in subequatorial areas seasonal variations may occur.

Savannas are characterized by a landscape that supports scattered trees in a tall grass cover. During dry periods the dried grasses catch fire easily. Therefore grasses adapted to withstand drought, naturally grow in savannas. These grasses have a very good underground connectivity. The few herbs found among grass cover contain small leaves to reduce transpiration and thorns to be protected from herbivores.

Seasonal rains encourage a fresh growth of grasses to compensate the loss of biomass due to consumption by herbivores.

Figure 8.7: A Savanna

Many insects (mainly termites), lions, zebras are the common animals in this region. Many animals have effective locomotion for long distance migration and long range vision for hunting. Human settlement from a very early time has been reported in these areas. Due to rearing of cattle and hunting of animals by humans the population of mammals have been decreased. Fires caused by human aid help to maintain the grass cover of this biome in one way but it may also have a negative impact by suppressing the growth of trees.

3. Desert

Desert is a temperate or tropical biome, commonly occurring near 30° north and south latitudes (e.g.Sahara), and in the center of continents (e.g. Gobi desert in north central Asia). The distribution of this biome is determined by the non availability of water such as in areas with annual average rainfall is less than 3000 mm per year.The temperature varies seasonally and daily and exceeds 50 °C in hot deserts while in cold deserts it drops below -30° C.

Deserts have more bare lands. If the vegetation is found they are sparse and widely scattered. Desert plants have several adaptations to withstand the high temperature and scarcity of water.

- Succulent plant body (e.g. Cacti and Euphorbs)
- Most plants have C4 pathway of photosysnthesis
- Deep roots in shrubs
- Ability to tolerate heat and desiccation
- Reduced surface area of leaves
- Presence of spines/ thorns
- Presence of toxins in leaves
-

Nocturnal animal species are abundant in deserts. Water conservation is a prominent feature, with some species surviving solely on water obtained during the breaking down of carbohydrates in seeds. Animals include, snakes, lizards, beetles, ants, scorpions, rodents and birds.

Since these areas are converted into human settlements and agricultural lands, the natural biodiversity is reduced. Deep wells and well developed systems for transporting water has facilitated human settlement and agricultural lands.

Figure 8.8 : A Desert

4.Chaparral

Chaparral occurs in mid latitude coastal regions such as North America, Chilie, Spain, Southern France and South Africa. Chaparral is best developed in Southern California.

Chaparrals receive an average annual rainfall of 300-500 mm. They experience rainy winters and dry summer. The average temperature is between 10 to 12 °C but can reach up to 40 °C.

The Chaparral biome is typically composed of dwarf forests and shrubs, and interspersed herbaceous vegetation which include grasses and herbs. Chaparral is highly prone to events of catastrophic wildfire. Therefore plants show the some of the following adaptations;

- Seed germination occurring only after a hot fire.
- fire resistant roots.
- Uses of food stored in the fire resistant roots for resprouting after a fire.
- Quick re -sprouting enables usage of nutrients released by the fire.
- Tough evergreen leaves in woody plants to survive in droughts.

Most of the native mammals in chaparrals are browsers. They include deers and goats. Chaparrals are rich in diversity of small mammals, and several species of amphibians, birds, reptiles and insects.

These areas have been reduced and disturbed due to human settlement, urbanization and agricultural conversions. Chaparral is vulnerable to fire caused by human activities.

5. Temperate grasslands

These grasslands occur under temperate climatic regimes that are intermediate to those that support forest and desert. Grasslands in North America are called prairie (they are often called

steppe in Eurasia and called pampas in Argentina).

Precipitation is highly seasonal with periodic drought. These grasslands have relatively dry winters and wet summers. The average rainfall is 300 to 1000 mm per year.
During winter seasons the average temperature falls below -10 °C and in summer it is about 30 °C.

Grasses are the dominant plant species in these grasslands. The prairie is often divided into three types according to height of the dominant vegetation—tall-grass, mixed-grass, and short-grass. The height of grasses vary from few centimeters to two meters in tall grass pairrie. Fire and droughts are occurred in these grasslands but many plants growing in those areas have adaptations to cope with fire.

Large grazers such as horses and many types of burrowing mammals (prairie dogs in North America) are found in these areas.

The tall-grass prairie is now an endangered natural ecosystem, because it has been almost entirely converted to agriculture and farmlands.

Figure 8.9 : Temperate grassland

6. Temperate broadleaf forest

Distribution of temperate broadleaf forests are at mid latitudes in the northern hemisphere. The average annual precipitation is between 700 to 2000 mm. Significant amount of precipitation is received throughout the year in summer as rain and in winter as snow.

Average temperature during winter is zero while in summer it is up to 35 °C. Summer is hot and humid and allow a favourable time to the growth of trees.

The dominant trees are mostly deciduous. A vertical layering (stratification) can be seen in temperate broadleaf forests. They are closed canopy layer, one or two strata of understory trees, shrub layer and herb layer. There are only few epiphytes can be found.
Many mammals can be seen and they hibernate during winter seasons while the birds species migrate to areas where climate is warmer.

Forests are disturbed due to logging, clearance for agriculture and for human settlements.

7. Northern coniferous forest

The largest biome on earth is the northern coniferous forest. It is extended as a broad band from upper band of Arctic tundra.

Precepitation: Annual average precipitation is around 300- 700 mm and a periodic drought is also common.

The temperature is -50^0 C in winter and 20 C^0 in summer.

The northern forest is dominated by coniferous trees. e.g. Fir, Pine, spruce are common tree species.

Many conifers are conical in shape and this shape of trees prevents accumulation of snow, thus preventing the breaking down of branches. They have needle like leaves that prevent high transpiration.

The diversity of shrubs and herbs in these forests is less than that of temperate broad leaf forests because of the limitations in precipitation and warm temperature.

Commonly found mammals are brown bears, moose, and siberan tigers. During some period of time dominant plants can be killed by sudden attacks of insects.

These areas are not heavily populated by humans, but logging is a severe threat.

Figure 8.10 : Northern coniferous forest

8. Tundra

This biome covers expansive areas of the arctic region, amounting 20% of earths land surface. Alpine tundra occurs at high altitudes on mountains, while arctic tundra occurs at high latitudes. Most tundras receive very small inputs of water as precipitation, but nevertheless their soil may be moist or wet because there is little evaporation in such cold climates, and deep drainage may be prevented by frozen soil.

The arctic tundra annually receive an average precipitation around 200 to 600 mm and the alpine tundra receives > 1000 mm precipitation respectively.

During the winter time temperature falls below -30 ^{0}C and during the summer temperature it is always less than 10^{0}C.

Mostly herbaceous plants can be seen that includes different types of grasses and forbs. Shrubs, mosses, lichens and trees also can be found in tundra. A layer of permafrost which is a permanently frozen layer of soil can be seen. This permafrost layer restrict the growth of the roots of plants.

Large grazing mammals such as Caribou and reindeer (migratory), musk oxen (resident) and predatory wolves, foxes, bears together with many species of migratory birds that nest during summer can be seen in this biome.

This area is sparsely colonized by humans, but heavily used for extraction of minerals and oils.

Figure 8.11 : The tundra

Ecosystems of Sri Lanka

Sri Lanka is in the north-equatorial tropical zone. Therefore it experiences a climate with high rainfall and temperature which permits the country to be blessed with a wide array of terrestrial and aquatic ecosystems. The ecosystems can be broadly classified into groups as follows.

1. Terrestrial ecosystems-
   a. Forests-Lowland rain forests, Dry monsoon forests, Montane forests, Thorn scrubs
   b. Grasslands- Savanna, patana
2. Inland wetland ecosystems- Rivers and streams, Reservoirs, Marshes and swamps, villus
3. Ecosystems is with coastal areas- Lagoons and estuaries, Mangroves, Coral reefs, Sea shore, Sand dunes, Sea grass beds, Salt marshes.

The distribution of major vegetation types may be considered as broadly linked to the local climate (mainly rain fall and temperature), topography, and the edaphic (soil) conditions. A broad classification of major ecosystems of Sri Lanka is given below.

Table 01:Classifications of eco systems in Sri Lanka

Climatic zone	Parameters T: temperature (^{0}C) R: Rainfall (mm) Alt: Altitude (m)	Forests	Grasslands	Other
Arid zone	T 32-36 R< 1000 Alt <300	Tropical thorn scrubs	Arid	Salt marsh Mangroves Sea shore Dunes Coastal marine, Reservoirs, rivers streams, and riverine Wetland Marshes Villus
Dry zone	T 28-32 R: 1000-1500 Alt< 500	Tropical dry mixed evergreen forests	Damana Talawa Savanna	
Intermediate zone	T 24-28 R 1250-2000 Alt 500-1500	Tropical moist evergreen forests, Tropical sub montane forests	Savanna Dry Patana	
Wet zone	T 16-28 R> 2000 Alt 300-1000 Alt 900-1500 Alt > 1500	Tropical lowland wet ever-green Tropical sub-mon-tane Tropical upper montane	Talawa Dry Patana Wet Patana	

Source; National Atlas of Sri Lanka, 2nd Edition, Survey department of Sri Lanka

Tropical wet low land rainforests:

The tropical wet lowland rainforests are found below 900 m elevation in the south western quarter of the country. The mean annual temperature is about 28 °C, and the mean annual rainfalls varies between 2000 mm- 5000 mm in different locations without any dry period. The humidity is very high.

These forests are characterized by a tall canopy, sub canopy and a sparse shrub layer consisting mostly of the saplings of canopy trees. Sometimes an emergent layer is also seen above the canopy.

The vegetation is filled with a network of woody lianas that reach to the canopy layer.

A diverse population of epiphytic lichens, mosses, liverworts ferns, orchids are found while many fungi inhabit decaying woods and soil. High endemism of floral and faunal diversity can be seen in these forests. E.g. Sinharaja, Nakiyadeniya and Kanneliya are some examples for wet lowlands rainforests. These forests are disturbed due to expansion of tea cultivation, agriculture, industrial and residential development.

Some tree species found in wet lowland rain forests are;

- S: Hora, T: Ennai (*Dipterocarpus zeylanicus*)
- S: Naa, T: Nagai (*Mesua ferrea*)
- S: Hal, T:Kungiliyam pinai (*Vateria copallifera*)

Some animal species found in the wet lowland rainforests are Purple faced langur, Sri Lanka slender loris, Golden wet zone palm civet.

Figure 8.12 : Tropical wet lowland rain forests

Tropical montane forests

They occur at elevation beyond 1500 m above mean sea level. The average temperature is about

16 °C and rainfall is about 2000 mm without any dry period. The humidity is high as lowland rain forests.

These forests are characterized by a short canopy of about 13 m, with a dense shrub layer. There are trees with umbrella- shaped rounded crowns and twisted branches having leathery small leaves to accommodate the strong winds that prevail in the montane zone. High density of epiphytes cover the branches and stems of trees. Some plants found in these forests are;

- S: Keena, T: Pongu (*Callophyllum walkeri*)
- S: Walkurudu, T: Kaatu karuwa (*Cinnamomum ovalifolium*)
- S: Gal weralu, E: wild olive (*Elaeocarpus montanus*)

Some animals that inhabit montane rainforests of Sri Lanka are Sri Lanka Yellow eared bulbul, Sri Lanka highland Shrew, Sambar.

Montane forests are distributed in central hills including Knuckles range, Piduruthalagala, Hakgala. Montane forests were greatly affected due to tea cultivation.

Figure 8.13 : Tropical montane forests

Tropical dry mixed evergreen forests/Dry monsoon forests

These forests have mean annual temperature of about 29 °C and rainfall around 1000 mm- 1500

mm., most of which falls during the northeast monsoon periods. There is a marked dry spell from May to August. Above forests are distributed in areas below 300m altitude.

These forests are characterized by having sparse canopy, a sub canopy and a well-developed shrub/herb layer. Some plant species naturally found in these forests are

- S: Weera T: Virai (*Drypetes sepiaraia*)
- S: Palu, T: Paalai (*Manilkara hexandra*)
- S: Kaluwara, T: Karun-kaali (*Diospyros ebenum*)

Some of the canopy trees are deciduous during the dry spell of the year. These forests harbor the largest elephant populations in Asia. The mammal fauna includes leopard, bear, deer. Most of the forests are protected as National parks such as Yala National park, Wilpattu National Park, Wasgamuwa National Park, Maduru-Oya national park, Ritigala Strict Nature reserve and many sanctuaries and forest reserves.

These forests are disturbed by 'chena' cultivation, human settlements, extraction of timber, poaching etc.

Figure 8.14: Tropical dry mixed evergreen forests

Tropical thorn scrubs

These are called "scrubs" than "forests" as large trees are sparse and the vegetation is mainly consists of thorny shrubs. They are found in arid lowlands. The mean annual temperature is around 31 °C and rainfall is below 1000 mm with a longer dry period.

The following plant species are commonly found ;

- S: Gini- andara , T:Vindattai (*Dichrostachys cineria*)
- S: Ranawara, T: Avaram poo (*Cassia auriculata*)
- S: Heeressa, T: Pirandai (*Cissus quadrangularis*)

Due to the dry conditions many fauna species cannot be found. However Deer, Leopard, elephants can be seen in these areas. They are distributed near Hambantota, Yala, Mannar, Puttalam areas and disturbed due to various development pressures.

Figure 8.15 : Tropical thorn scrubs

Savanna

Savannas have a thick grass cover and few scattered trees. These are common on hill slopes of the dry or intermediate zone. The thin layer of soil on hill slopes cannot support the growth of trees and the grass cover of savannas helps to bind soil particles and reduce erosion of soil. Periodic fires are common to this ecosystem as the fried grass cover easily catch fire in dry period of the year. They have trees with fire resistant species.

Some plant species found in Savanna are trees are;

- S: Aralu, T: Kadukkay (*Terminalia chebula*)
- S: Nelli, T: Topu- nelli (*Phyllanthus emblica*)
- S: bulu , T: Adhan- koddai, tanti (*Terminalia bellirica*) and
- have grass species such as
- S: Mana, E: Citronella grass , Vasanai pullu (T) (*Cymbopogon nardus*)
- S: Iluk E: Cogon grass T:Tharpai pullu (*Imperata cylindrica*)

Savannas are seen in Bibile, Monaragala, Mahiyanganaya, Wellawaya areas. These are distributed

by periodic fires set by villagers for various reasons.

Patana

There are two types of 'Patana' found in Sri Lanka; wet patana grassland and dry patana grassland based on the rainfall pattern and soil of the site.

'Wet Patana' grass lands are found in areas above 1500 m from the sea level with mean annual rainfall of over 2000 mm. Temperature ranges from 5°C to 18° C. Mist, fog and frost are common in these areas and do not experience any dry period.

The grasses do not reach more than one meter height and are called tussock grasses which include the *Chrysopogon nodulibarbis* and *Arundinella villosa*. The animals include a large Sambar and Wild- boare populations and few leopards. Extensive "Wet Patana" are found only in Horton plains.

Dry patana grasslands are found in altitudes between 500 m to 1600 m. They receive a rainfall about 1400 mm to 2000 mm with a definite dry period. Temperature ranges from 18°C to 24° C. The vegetation is made up of grasses that grow up to 1-2 m height such as Pangiri mana (*Cymbopogon nardus*) and *Themeda/* (Pini bara tana)/ *Themeda tremula*.

"Dry Patana" is common on hill tops in in Hantana, Gampola, Welimada, and Haputale .

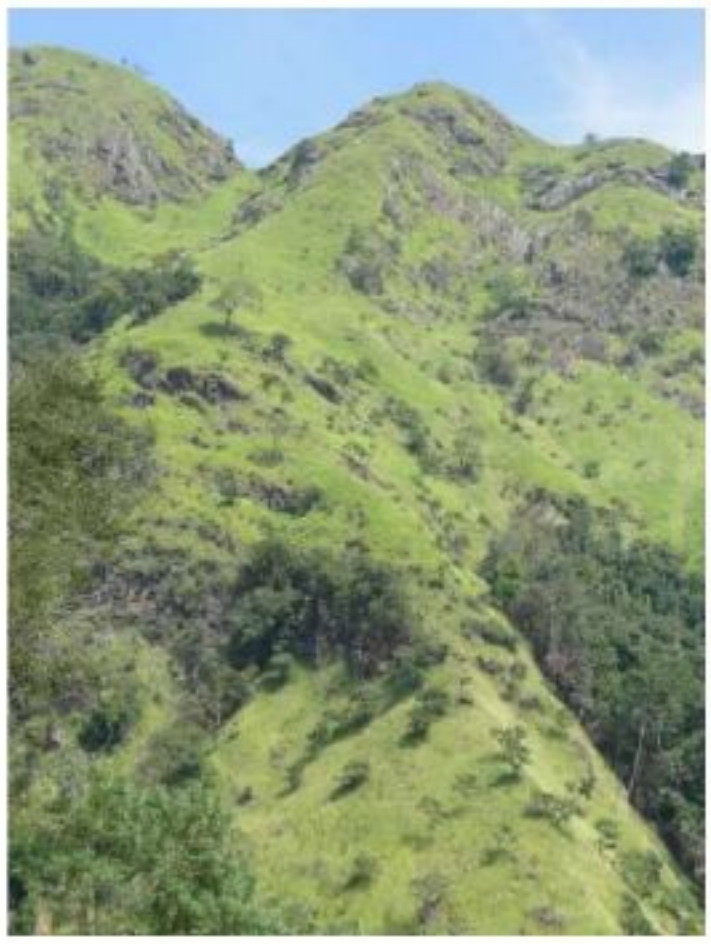


Figure 8.16 : Dry Patana

Figure 8.17 : Wet Patana

Wetlands

Wetlands are simply habitats with permanent or temporary accumulation of water with associated plant and animals. According to Ramsar Convention, wetlands are defined as areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide not exceed six metres. The wetlands of Sri Lanka, which fit into the Ramsar definition, can be divided into three broad categories:

- Inland fresh water wetlands (e.g. rivers, stream, marshes, swamp forests and villus)
- Coastal wetlands (e.g. lagoons, estuaries, mangroves, sea grass beds, salt marshes and coral reefs)
- Man-made wetlands (e.g. tanks, reservoirs, rice fields and salterns)

Rivers and streams

Sri Lanka has an extensive network of rivers, which drains a total of 103 distinct natural river basins. The river basins originating in the wet highlands are perennial, while many of those in dry zone are seasonal. There is hardly any vegetation to be found in running water.

Figure 8.18 : Streams

Marshes and swamp forests

Inland freshwater marshlands are low lying areas which receive water through surface runoff, ground water seepage or flood water from rivers. These contain peat (partially decomposed organic matter), and water logged sticky clay soil. Many water birds, amphibians and fish species inhabit these areas. Plants that have adapted to grow in shallow stagnant water such as habarala (S) / Semaikilangu (T)- *Colocasia* species, Kekatiya (S)- *Aponogeton* spp, Reeds (E)/ Pan (S) species are abundant in inland marshlands.

Freshwater swamp forests are not common in Sri Lanka. It is a place where forest vegetation is inundated for a short period of time in the year as seen in the Waturana swamp at Bulathsinhala located in the 'kalu ganga basin'.

Villus

Generally villus are the flood plains of the reservoirs. Villu grasslands possess a special link with

the wildlife in the area, especially elephants and bird populations. The vegetation is dominant with grasses (members of Poaceae) and sedges (members of Cyperaceae). Villu grasslands are located in areas such as Mahawelli flood plains, Wilpattu National park etc.

Figure 8.19 : Villu

Lagoons and Estuaries

Lagoons are coastal wetlands generally separated from the sea by a sand barrier. Eg: Negambo and Bundala lagoons. Estuaries are formed in places where rivers enter the sea and does not contain a sand barrier separating it from seas (e.g. Maduganga/Benthota). The daily tidal fluctuation is a characteristic of these places.

Mangroves

Mangroves ecosystem is an intertidal vegetation that covers fringes of the lagoons and estuaries. They share characteristics usually of saline/brackish water, loose soil and anoxic conditions. The vegetation is also exposed to intense sunlight.

Mangrove plants could be categorized into two groups; true mangroves that occur towards the boundary between sea and land and mangrove associates that occur more towards inland

Common true mangrove species are;

- S: kadol, T: kandal. (*Rhizophora* spp, *Bruguiera* spp,)
- S: Mas athu gas T: kannamaram (*Avicennia marina*)

Common mangrove associates are:

- S: Karan Koku, E: Golden leather fern (*Acrostichum aureu)* S:Katu- ikili E: Holly mangrove (*Acanthus ilicifolius*)

In order to protect from sunlight leaves of mangrove have a thick cuticle to reflect sunrays and/ or cut off excess radiation. Some have salt glands to secrete excess salts that are absorbed by the plants. There are special roots to intake atmospheric oxygen. Seeds of some mangroves germinate while attached to the mother plant (vivipary). This help the seed to establish successfully soon after falling from the tree.

Mangroves provide a unique habitat mainly for many crustaceans and mollusks.

Mangroves are found in Puttalam, Batticaloa, Trincomalee and Galle.Bentota and Negambo.

Figure 8.20 : Mangroves

Salt marshes

These are marshlands restricted to the arid coastal regions of the country where soil dries up to form crystals of salts during the dry season. Low rainfall, high wind, high temperatures and loose sand blowing with salt are some of the major characteristics found in this ecosystem.

The vegetation has only few plant and animal species . Plants are short, contain fleshy succulent plant bodies One common plant species is *Salicornia* sp. Salt marshes are common in Puttalam, Mannar, Hambantota and Vakarai areas.

Figure 8.21 : Salt Marsh

Sea grass beds

In large lagoon areas with low wave action, the floor of the shallow sea is occupied by sea grasses. These are not grass species but appear like grasses due to the shape of leaves. E.g. Plant species such as *Halodule* spp and *Halophyla* spp. are common sea grasses found in Sri Lanka (especially

from Kalpitiya to Mannnar. Sea grasses grow in a compact cluster and provides the sea bed a favourable habitat for breeding of many fish species. However, these areas are often disturbed by the fisheries activities as these are the parking areas of fishing boats.

Figure 8.22 : Sea grass bed

Coral reefs

Coral reefs are one of the natural wonders of the world. Coral reefs consist of calcareous structures secreted by a group of marine invertebrates. Coral reefs are famous for their spectacular beauty. They are considered as 'rain forests of the sea' because of their high productivity and high diversity of organisms inhabit them. Coral reefs can be seen in southern coast (Akurala to Tangalle), Gulf of Mannar, etc.

The reefs are habitats for a large number of fish species, invertebrates such as spiny lobsters, sea cucumbers, etc. Marine mammals and reptiles such as dolphins and sea turtles inhabit reefs occassionally.

Figure 8.23 : Coral reefs

Reservoirs

There are no natural lakes in Sri Lanka, but there are numerous ancient irrigation tanks mainly

scattered in the lowland dry zone. Typical irrigation tanks include 'Parakrama samudra', 'Kala wewa', 'Minneriya wewa and tissawewa.

Aquatic plant species commonly found in the reservoirs are

- S: Manel, E: Water lily (*Nymphaea* spp),
- S: Nelum. T: Tamarai (*Nelumbo nucifera*)
- S: Kekatiya, T: Koddi (*Aponogeton* spp).

Often free floating invasive alien plant species such as *Salvinia* and Japan jabara (S)/ water hyacinth (E) also can be seen in these tanks.

Figure8.24 : Reservoirs

Sea shore

The long sea shore of Sri Lanka varies in nature. The most common sea shore type is sandy sea shores. The sea shore areas share the characteristics of high temperature throughout, and salt spray and high winds especially during the monsoon seasons. Most of the sea shore plants have adapted to these conditions. Examples for these plants are Muhudu Binthamburu (S), Beach Morning Glory (E)- atampu (T) (*Ipomea pescaprae*), Maha rawana revula (S), Ravannan meesai (T)- *Spinifex littoreus* .

The vegetation gradually become stable a distance away from the tide mark, with the stabilization of the soil. In these areas plant species such as wara (S)/ erukkalai (T)- (*Calotropis gigantea*), Wetakeiya (S)/ talai (T)- *Pandanus* spp etc. can be found.

Figure 8.25 : Sea shore

Sand Dunes

Dunes are characterized by stunted or creping vegetation on large masses of sand. The sand dune structure is determined by wind speed and direction. Dunes are raised beaches of sand and are characteristic of certain coastal areas in the arid zone. Eg: near Mullativu,

Figure 8.26 : Sand dunes

Biodiversity

Definitions

Biodiversity includes all forms of "life" on earth.

Biodiversity is the variability among living organisms from all sources including terrestrial, marine, and other aquatic ecosystems and their ecological interactions with the environment. Biodiversity is explained under three levels. They are genetic diversity, species diversity and ecosystem diversity.

a. Genetic diversity

The basic component of biological diversity is the genetic variation that exists both within and among species. This genetic variation is the basis for evolution.

b. Species diversity

This is simply the variation that can be recognized among different species. It includes the number of species (=species richness) and their abundance.

c. Ecosystem diversity is the variety of habitats, living communities and ecological processes in the living world.

Ecosystem diversity is the largest scale of biodiversity, and within each ecosystem, there is a great deal of both species and genetic diversity incorperated.

Ecosystem diversity on a global scale would be the variation in ecosystems in large regions (biomes) such as deserts, forests, grasslands, wetlands and oceans whereas in smaller localized regions it can be explained by means of different ecosystems.

The importance and values of biodiversity

The individual components of biodiversity—genes, species, and ecosystems provide the human society with a wide array of goods and services. Genes, species, and ecosystems of direct, indirect, or potential use to humanity are often referred to as "biological resources". Genes are used by plant breeders to develop new crop varieties. Many species are used as various foods, medicines, fibers, fuels and industrial products. This include food resources like grains, vegetables, fruits which are obtained from plant resources and meat, fish, egg, milk and milk products from animal resources. The biodiversity products can be harvested and consumed directly without passing through a formal market (non commercial goods). Example: fruits, fish, edible roots, leaves, nuts, flowers, meat, animal product like milk and honey, timber, firewood, fiber, wool, wax, resin, rubber, silk and decorative items, and traditional medicines, etc. Some products can be harvested and available through a formal market (commercial goods). Many industries such as food, textile, leather, silk, paper pulp are based on the direct use of biological resources. The ecosystems provide many services to us, such as air and water purification, erosion prevention and flood control.

Therefore the value of biodiversity is explained through its "goods" and "services" provided to humanity and sustenance of the environment.

- **Environmental service value**: This is the most important services provided by biodiversity in maintaining critical environmental functions. E.g. Carbon dioxide fixation through photosynthesis, maintaining of essential nutrition cycles, maintaining water cycle and recharging of ground water, soil formation and protection from erosion, regulating climate by recycling moisture into the atmosphere, water purification, pollination, etc.
- **Recreational value**: There is a great aesthetic value provided by biodiversity. Natural landscapes at undisturbed places are a delight to watch and also provide opportunities for recreational activities and hobbies such as bird watching, photography etc. Biodiversity provides inspiration in artistic activities like poetry, painting, dance etc. It promotes eco-tourism, helps to generate revenue by designing of zoological, botanical gardens, national parks etc.
- **Ethical value**: This is the right of all living beings to live on this planet, humans have no right to decide which species should exist since we are just a small part of the greater creation of nature.
- **Educational/Scientific value**: knowledge about biodiversity helps in new scientific discoveries and technological innovations to find solutions to the problems we face today. E.g. learning of other animals like nematodes, rats and primates has helped in understanding human body and development of medicines, knowledge about how animals react before a natural disaster is helpful in disaster management, Interacting with biodiversity is proven to be helpful in developing creativity, relieving stress and development of personality.
- **Social/Cultural/Religious values**: Biodiversity can be important to different societies and communities due to unique reasons E.g. Some wetland sites are sacred to Aborigines of Australia, twenty eight species of trees are sacred for Buddhists, Bulls are considered to be an important part of Hindu culture.

Figure 8.27 : Recreational value of BiodiversityLoss of biodiversity

Animal and plant species die off all the time. It's how the biological world rolls. However, things have changed dramatically in recent decades. According to some scientists, Earth is currently in the midst of its sixth mass extinction. The last major extinction occurred some 65 million years ago, when a large asteroid slammed off the coast of Mexico, killing off the dinosaurs and most everything else. Today, scientists say the extinction rate is as much as 1,000 times faster than what should be natural rate would be.This is solely because of the very high and negative impact of humans on biodiversity due to high population and development. Virtually all of Earth's ecosystems have been dramatically transformed through human actions, for example, many mangrove and coral reef areas have been lost. Within groups of conifers, cycads, amphibians, birds, and mammals up to 50% of species are threatened with extinction, according to the IUCN Red List. Within many species groups, such as amphibians, African mammals, and birds in agricultural lands, the majority of species have faced a decline in the size of their population, in their geographical spread, or both.

Threats to biodiversity

Habitat loss/fragmentation: Humans supplant natural ecosystems to grow food, harvest materials, and build our settlements. These actions alter or eliminate the conditions needed for plants and animals to survive. When natural habitats are converted into other human uses such as agriculture or built up area they are no longer able to support the species present in the original habitat. This result in the displacement or destruction of biodiversity. E.g. deforestation, filling of wetlands

Mass scale destruction of Mangrove in lagoons such as Negambo and Puttalam due to establishment of prawn culture destructed the biodiversity of mangroves in these areas.

Figure 8.28 : Habitat loss

When habitats are divided into fragments due to establishment of man built structures such as roads, the animals and plant species are forced to occupy smaller area in a crowded manner which

is harder for biodiversity to sustain as in previous habitat conditions.

Overexploitation: Harvesting or exploiting biodiversity products in a manner and a rate which it cannot recover within the periods of exploitation leads to danger of biodiversity being completely lost.

E.g. Over collection of indigenous medicinal plants from forests in Sri Lanka for export such as Kotalahimbutu (S)/ - (*Salacia reticulata*). Export of sea cucumber for medicinal purposes from Sri Lankan shores. *Ebony*(E)/Kaluwara (S), Karun-kaali (T)- (*Diospyrus ebanum)* is threatened due to over exploitation during the colonial period. Ebony has a very slow growth rate and take many years to grow. Intense commercial fishing has led to over fishing threatening decline of food fish like Tuna and Cod in world's oceans.

Pollution: Pollution simply means addition of unwanted materials to air, water, soil. Due to extensive use of agrochemicals that wash away with rain water into the water bodies make the water rich in nutrients (eutrophication) resulting in algal blooms. Algal blooms create oxygen-depleted zone in aquatic ecosystems and greatly reduce the populations of fish and other aquatic species.

Uses of synthetic fertilizers for tea in montane areas also has resulted pollution of rivers in many down stream areas affecting the water quality and making it unsuitable for human use

Releasing of Sulphur dioxide (SO_2) and nitrous oxide (N_2O) gasses react with water and make the rain water acidic resulting acid rains. Acid rains caused by air pollution contributes to the death of trees killing many buds, leaves and the seedlings and causing damage to the plant roots.

Figure 8.29 : Water pollution affects aquatic biodiversity.

Introduction of invasive alien species: Invasive alien species are alien (exotic) plants and/or animals whose introduction and spread outside their natural geographic range threaten native biodiversity. Alien invasive species compete against or prey on native species, which can lead

to their extinction. Once introduced , for a considerable period of time, they may lack natural predators in the new environment. This is a great opportunity for them to reproduces successfully and spread without limits to take over the environment. They can transport disease, out-compete native species, alter food chains, decrease biodiversity, and even change ecosystems properties by altering soil composition or creating habitats that encourage wildfires. E.g. Alien invasive species such as Lantana(E)/ Gandapana (S) / Nayunni (T)-(*Lantana camara*) does not allow germination and seedling growth of many other plants as it produces toxins which are added to soil through leaf litter. Extensive spread of Guinea grass(E)/ Gini- thana (S)/ Ginipullu (T) (*Panicum maximum*) in especially in the dry pathana areas facilitates fire due to its dry biomass during drought seasons.

Figure 8.30 : *Lantana* (Gandapana)

Climate change: Climate change is predicted to be the greatest long-term threat to biodiversity. Increasing temperatures and temperature extremes, increasingly severe droughts, rising sea levels, possible decrease in rainfall, regional flooding and reduced water availability change ecosystems. Many species will not be able to adapt themselves fast enough to keep up with the coming changes driving them to extinction or being endangered. Evidence suggests that the warming of the past century already has resulted in marked ecological changes, such as changes in growing seasons of crop species, distribution ranges, and patterns of seasonal breeding of animals.

Biodiversity hot spots- The areas with a high concentration of endemic species facing exceptional levels of threats have been described by Myers in 1988 as biodiversity hotspots. As a whole Sri Lanka has a high degree of endemism. Sri Lanka (wet zone of Sri Lanka) together with Western Ghats of India is considered as one of the Biodiversity hot spot in South Asian region.

Extinction of species

- Existing species have to make room for new species either by changing themselves or by becoming extinct. Therefore natural extinction has to be recognized as part of the evolutionary process.
- The rate of evolution has been generally higher than that of extinction. Therefor there has been an increase in Biodiversity over time.
- Extinction is the elimination of the last member of a species from the earth.
- With the growth of human population and civilization, mankind has greatly increased the rate of extinction.
- The earth today is dominated by humans and no ecosystems on earth's surface is free from human influence.
- In general it is estimated that about 5-10% of the species may face extinction within the next 30 years.

Not only a species but also family or genus or a sub species (taxon) can become extinct if there had been a continuous pressure for its survival. The Red Data book published by the International Union for Conservation of Nature (IUCN) provides a list of threatened species and definie extinct and threatened species as follows.

EXTINCT (EX)

A taxon is Extinct when there is no reasonable doubt that the last individual has died. E.g. Dodo (Lived in Mauritius), Wooly Mammoth (Lived in North America), Legume (*Crudia zeylanica*)

Figure 8.31 : *Dodo*

Extinct in the wild (EW): A taxon is extinct in the wild when it is known only to survive in cultivation, in captivity or as a naturalized population (populations) well outside its natural habitat. E.g; Giant tortoise of Seychelles

Different categories of threatened organisms:

A species is said to be 'threatened' when it is about to leave the world. Threatened organisms are described under three categories. Critically endangered, endangered and vulnerable. The red data book has indicated other categories such as nearly threatened, least concern etc , but these are not considered as a ' threatened species.

CRITICALLY ENDANGERED (CR)

A taxon is critically endangered when the best available evidence indicates that it is facing an extremely high risk of extinction in the wild. Marbled rock frog (E)/Dumbaragalparadiyamadiya (S) and Maha madu (S)/ Ratchatha madupunai (T)- can be listed as one example to represent animals and plants critically endangered in Sri Lanka.

ENDANGERED (EN)

A taxon is endangered when the best available evidence indicates that it is facing a **very high risk** of extinction in the wild. Eg: Etha / Aliya (S)/ Yanai (T), Elephant (E), Wesak Orhid (S/E/T)

VULNERABLE (VU)

A taxon is vulnerable when the best available evidence indicates that it is facing a high risk of extinction in the wild. Punchi Leena (S)/ Dusky-striped, jungle squirrel (E) and Buttercup (E)- are among the vulnerable species found in Sri Lanka .

Endemic species:

An endemic species is a species that is confined to a particular area or country, and not found growing **naturally** anywhere else in the world.

Two examples for plant species endemic to Sri Lanka are:

Dipterocarpus zeylanicus(S: Hora, T: Ennai)

Garcinia quaesita (S: Goraka, T: Gorakappuli)

Examples of two animal species endemic to Sri Lanka are;

Puntius nigrofasciatus (E: Black ruby barb, S: Bulathhapaya, T: Veddiyan)

Loris tardigradus (E: Slender loris, S:Unahapuluwa, T:Thevangu)

Figure 8.32 : Black rubby barb

Indigenous species: A plant or animal species that occurs in its historically known natural range and that forms part of the natural biological diversity of a particular geographic area.

Examples from Sri Lankan indigenous species are:

Lula(S)/ Snake head (E)/ Viral (T)

Kitul(S)/ Thippilipanai (T)

Exotic (alien) species: A species that has been introduced from another geographic region to an area outside its natural range due to human activities. The introduction of species can be intentional or accidental. The following examples represent examples for intentional and direct introductions. Accidental introductions are indirect introductions often considered as 'contaminations' of direct introductions.

Tilapia (S/E), Japan meen (T) for inland fishery industry.

Rubber (S/T), Rupper (T) for plantation industry.

Figure 8.33: Tilapia

Migratory Species: Migration refers to the act of moving from one place to another in a manner that is seasonally determined and predictable. Migration takes place so that organisms can avoid unfavorable environmental conditions that limit breeding.

Suduredi hora(S)/ Indian fly catcher(E) /Inthianeepidipan (T)

Avichchiya (S)/Indian pitta- (E)/ Aarumanikuruvi (T)

Figure 8. 34 : Indian fly catcher

Relict species: The remnants of a once widespread species, which are now found in very restricted or isolated areas, due to fact that areas in which these species are found is lost in many parts of the world.

The Tuatara is an example which lives only on a few small islands of New Zealand. - *Ichthyophis* a primitive ancient legless amphibians with a worm like body. *Lingula* found in Tambalagamuwa bay in Trincomalee is an example for a relict species in Sri Lanka.

Flagship species: Flagship species is a species chosen as a symbol or icon to represent an ecosystem in need for conservation. These species are chosen for their vulnerability, attractiveness or distinctiveness in order to bring about support and acknowledgement from the public at large. Thus, the concept of a flagship species is that the publicity given to few key species, will help the conservation of entire ecosystem and all species contained therein.

The Bengal tiger of India, the giant panda of China, Blue magpie of Sri Lanka- (S: Lanka kehibella, T: Neelavudalperumkuyil) are examples.

Figure 35: Blue magpie

Keystone species: These are species that play a very important role in the stability and functioning of a system. If that species is removed the system tends to collapse. e.g. Planktons of a pond

Invasive alien species- : Invasive alien species are alien (exotic) plants and/or animals whose introduction and spread outside their natural geographic range threaten native biodiversity. Invasive alien species take the advantage of 'human disturbances' in the environment to establish and spread themselves. Their capability to tolerate wide range of environment conditions and high reproductive output help them to easily and successfully expand their populations. Although only a small percentage of alien species become invasive they damage biodiversity (ecosystem, species and genetic levels) in everywhere they invade and alter the services and ecosystem

values of the introduced environment. Therefore invasive alien species are considered as a major cause for depletion of biodiversity and environment degradation. The following examples represent invasive alien animal and plant species in Sri Lanka .

Kalutara Golubella (S)/ Giant African land snail (E) was introduced to Sri Lanka as a contamination of soil brought with some other plants. The soil contained eggs of the snail. Japan jabara (S)/ Water Hyacinth (E)/ Kulavazhai (T) was introduced to the country in nearly 110 years ago as an ornamental plant not knowing that it will become a serious invader afterwards.

Conservation

A principal goal of conservation is to ensure the long term survival of as many species as possible. Species that are in danger of extinction have to be specially protected and steps should be taken to ensure their continued reproduction and survival. Conservation can be done in two ways.

***In-situ* conservation:** The species is protected and its reproduction facilitated in its natural habitat. Basically a large enough population and adequate, appropriate, habitat space has to be ensured. E.g. National parks such as Yala and Minneriya national parks, Forest reserves such as Kanneliya, Piduruthalagala

***Ex-situ* conservation:** The species is taken out of its natural habitats, and looked after in places where its survival and reproduction are ensured.
Zoological gardens and Botanical gardens of a country play a key role in *ex-situ* conservation.

Global Warming and Climate Change

Definition

Climate change refers to a significant, long-term changes of climate attributed directly or indirectly to human activity, that alters the composition of the global atmosphere in addition to natural climate variability observed over comparable time periods (United Nations Framework Convention on Climate Change /UNFCCC, 2011). In the meantime, the Intergovernmental Panel on Climate Change (IPCC) defined the climate change as "a statistically significant change in the state of the properties of the climate which persists for an extended period, typically decades or longer". This definitions refer to any change in climate over time, whether due to natural variability or as a result of human activity.

Global warming is the increase the average temperature of the Earth's surface (atmospheric and

oceanic temperatures) due to enhanced greenhouse effect [or Greenhouse gasses, (GHG)].

Climate change includes warming and the effects arisen due to warming such as melting glaciers, extremes of rains or more frequent drought etc. It can say in another way, global warming is one symptom of much larger problem of climate change.

Contributing factors on global warming and climate change

1. Increase of the emission of CO_2 and other greenhouse gasses (GHG) due to human activities

1.1 Carbon Dioxide (CO_2) is produced by burning of organic matters and it is the most common greenhouse gas to contribute to the global warming and climate change events. Burning of fossil fuel (for running vehicles, electricity generation, industries etc.) is the main cause of the emitting of CO_2 and burning of forests, solid waste are the other main causes contributing the CO_2 emission.

1.2 Methane (CH_4) is another greenhouse gas which has a higher global warming potential. Main emitting sources are anaerobic decomposing (at manure management and waste management), cattle farming, paddy cultivation and enteric fermentation. Even though the CH_4 is a greenhouse gas with high global warming potential, it is less abundant in the atmosphere compared to CO_2.

1.3 Nitrous oxide is (N_2O) another greenhouse gas also with higher global warming potential which is mainly released as by product of fertilizer production and use, other industrial processes, the combustion of certain materials (biomass), nitric acid production, and fossil fuel combustion in internal combustion engines. Nitrous oxide can remain very long time in the atmosphere.

1.4 Manmade industrial gases, namely, Perfluorocarbons (PFCs), Hydrofluorocarbons (HFCs) and Sulfur Hexafluoride (SF_6) are also considered as greenhouse gases with a very high global warming potential.

1.5 Black carbon or the carbon particles which are suspended in lower atmosphere also identified as another cause for global warming. Those particles released as a result of the incomplete combustion of fossil fuels, and other organic matters. These particles are extremely small, ranging from 10 μm 2.5 μm. These Black Carbon have an enormous ability to absorb heart and it cause to increase the air temperature. These particles have ability to absorb heat than CO_2.

Carbon monoxide (CO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), tropospheric (ground level) ozone (O_3), and nitrogen oxides (NOx) are also considered as gases which have indirect radiative forcing effect. Water vapor, non-methane volatile organic compounds (NMVOCs), and Aerosols are also considered as GHGs.

2. **Deforestation and decrease of the vegetation cover of the world**

   Deforestation is another main cause for global warming. At present the conversion of tropical forest lands to commercial agricultural plantations like palm oil contributes to the mass deforestation all over the world. Forests remove carbon dioxide from the atmosphere and fix through photosynthesis (carbon sequestration). Deforestation reduce the carbon sequestration capacity, carbon capture on the planet (i.e soil carbon) and increase the atmospheric CO_2 concentration.

3. **Destroying the large quantity of phytoplankton by UV radiation due to the deple tion of the ozone layer.**

   This is also similar to deforestation. Phytoplankton which live in warm seas are very useful to maintain the Oxygen and carbon dioxide balance. Normally the carbon absorption capacity of phytoplankton are higher than terrestrial plants. Though the phytoplankton are unicellular microscopic organism they have been distributed in large area and they were responsible for the 60%-70% of absorption of atmospheric carbon. Due to depletion of the ozone layer UV radiation which comes from sun can destroy this kind of tiny organisms and may cause to reduce the CO_2 absorption capacity of oceans and increase the global temperature.

Effects of the global warming and climate change

1. **Sea level rising**

   Scientists predict an increase in sea levels worldwide due to the melting of two massive ice sheets in polar regions and thermal expansion of water. However, many island nations around the world will experience the effects of sea level rise.

2. **Extreme weather events**

   Occurrence of extreme weather events such as prolong drought, intensive rainfall and its effects such as floods and landslides and storms have been increased for last decades was considered as a negative impact of climate change. It causes loss, damages and disasters.

3. **Less production of foods (Threat to food security)**

   Due to unexpected extreme weather condition the crop production will be getting loss around the world. It may be due to heavy rains or the severe droughts.

4. **Degradation of coral reefs**

   The corals bleaching and degradation due to rises in sea temperature is a severe danger for whole ocean ecosystems and many other species which lives on coral reefs for their survival. According to the recent reports coral populations will collapse by 2100 due to increased temperatures and ocean acidification and its effects

5. **Increase the insect population.**
   Due to increase of the insect population some diseases such as mosquito-borne malaria and dengue will spread than present. As well the over growth of the insect populations will be a massive threat to food production

6. **Loss of Biodiversity**
   Climate change and global warming may cause reduced biodiversity, Ecosystems structure will be change and some species may move from their present range of occurrence and may survive while some others will not be able to move and could become extinct.

Ozone Layer depletion

Most ozone particles are concentrated in the region of stratosphere in between 10-50 km of the atmosphere, and this layer is identified as the 'Ozone Layer'. This is very much important to protect living things from burning from too much ultraviolet (UV) radiation emitting from the sun

Naturally, the total concentration of ozone in the stratosphere remains relatively constant with the concentration of 300 to 350 Dobson Units (D.U). Ozone depletion is described when levels fall below 200 D.U due to man-made ozone depleting chemicals (ODCs) as in the stratosphere over the South Polar Region. This thinning of the ozone layer refers as Ozone hole.

Contribution factors for the Ozone layer depletion

Ozone depletion occurs when the natural balance between the production and destruction of stratospheric ozone is disturbed or lost. This is mainly due to chlorine and bromine released from man-made compounds called ozone depleting substance such as CFCs, MeBr, Helene and HCFC.

Effects of the Ozone Layer depletion

Depletion of the ozone layer in the stratosphere will increase penetration of solar UV-B radiation which is likely to have profound impact on human health with potential risks of eye diseases, skin cancer and infectious diseases.

It is a known fact that the physiological and developmental processes of plants are affected by UV-B radiation.

UV-B radiation is likely to result in changes in species composition (mutation) thus altering the bio-diversity in different ecosystems. It directly destroyed phytoplankton which form the foundation of aquatic food webs in the sea and it cause to reduce the composition of food web in the sea ecosystem.
UV-B can also cause damage to early development stages of fish, shrimp, crab, amphibians and other animals.

Desertification

Desertification means "process of land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities."(UNCCD, Paris, 1994),

Contribution factors for desertification

The main driving forces of desertification can be separated into climate variations and human activities, according to the UNCCD definition. It is known that human activities have a great influence in the climate change and it has caused desertification

Deforestation is another main factor to decertification because of it is directly influencing to reduce the rainfall, precipitation, soil humidity and water recharge of underground reservoirs

Over-exploitation of water and soil, uncontrolled mining and excessive use of agro-chemical products and as well as poor land management practices also caused to desertification.

Effects of the Desertification

Decrease ecosystems services and reduced biodiversity in affected areas. Decreasing of the vegetation cover induce water scarcity, destroys habitats of animal and plant species and reduces agricultural activities mainly the growth of crop species. It may effect to the food security of the people as well as for the animals. The process of desertification presents a serious impact on the human well-being and health of the people living in the areas affected by droughts and land degradation

Due to the desertification carbon storage capacity of plants and soils will also be reduced in the long run.

Acid rains

Acid rain is one of the most serious global environmental issue which, emerged due to air pollution mainly due to Sulphur dioxide (SO_2) and oxides of nitrogen. These pollutants are released from anthropogenic activities such as combustion of solid waste, fossil fuels in thermal power plants and vehicle engines.

Acid rain is a commonly used term for acid deposition, which includes rain, snow, fog and dry particles that fall from the sky. Uncontaminated precipitation is also slightly acidic and normal rain water may be about a 5.6 on the pH scale because carbon dioxide is dissolved and carbonic

acid is formed. Acid rain may show a lesser pH.

Contributing Factors of Acid Rains

Mainly caused by the release of sulfur dioxide and nitrogen oxides into the atmosphere due to burning of fossil fuels, where they are converted into sulfuric and nitric acid respectively.

Effects of the Acid Rains

Acid rain directly causes severe damage to building structures and marble statues

Increases the acidity of fresh water ecosystems such as streams, lakes, and marshes and it causes to change the structure and the composition of above fresh eater ecosystems.

Cause to destroy soil organisms and loss the soil fertility.

It cause to leach metals such as copper, aluminum, and some heavy metals such as lead and mercury in the soil and into runoff as well as drinking water

Acid rain causes significant damage to forests. It directly affects trees and other small plants which are important to the ecosystem

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)-1975

The aim of CITES is to ensure that international trade of specimens such as horns and skins of wild animals and whole plant or parts of plants does not threaten their survival. According to CITES, the export of some species (as listed) requires prior permission and presentation of an export permit. An export permit shall be granted only if export of that species will not be detrimental to that species survival. Some examples from Sri Lanka are skin of Sri Lankan Leopard (S: Kotiya, T: Siruththaipuli), plants of *Cycas* - Madu (S) / Madupanai (E).

Conventions related to conservation of the environment

Convention on Biological Diversity (CBD)- 1992

The Convention on Biological Diversity (CBD), known informally as the Biodiversity Convention, addresses all aspects of Biodiversity conservation.

It has three main goals:

- the conservation of biological diversity (or biodiversity)- e.g. conservation of genetic materials and species and ecosystems.
- the sustainable use of components of biological diversity- e.g. imposing limits to control overexploitation.

- The fair and equitable sharing of benefits arising from genetic resources- e.g. exchange of genetic material, species between countries without conflict.

The Convention on Wetlands (Ramsar Convention)-1971

The Convention on Wetlands, called the Ramsar Convention, provides the framework for the conservation and wise use of wetlands and their resources. In Sri Lanka, there are six wetlands declared as Ramsar sites: Anawilundawa, Bundala, Kumana, Maduganga, Vankalai and Wilpattu.

Figure 8.36 : Anawilundawa wetland

International Convention for the Prevention of Pollution from Ships (MARPOL)- 1973

International Convention for the Prevention of Pollution from Ships (MARPOL) is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. The objective of this convention is to preserve the marine environment in an attempt to completely eliminate pollution by oil and other harmful substances and to minimize accidental spillage of such substances.

Montreal Protocol- 1989

Montreal Protocol on Substances that Deplete the Ozone Layer is an international treaty designed to protect the ozone layer by phasing out the production of numerous substances that are responsible for ozone depletion.

Kyoto Protocol-1977

The Kyoto Protocol is an international agreement linked to the United Nations Framework Convention on Climate Change (UNFCCC), which commits its Parties by setting internationally binding green house gases (GHGs) emission reduction targets. In 2012 Doha, Qatar, the "Doha Amendment to the Kyoto Protocol" was adopted. During this commitment period (2013-2020)

parties are committed to reduce GHG emissions by at least 18 percent.

Basel Convention -1989

The Basel Convention on the Control of trans boundary movements of hazardous wastes and their Disposal intends to protect human health and the environment against the adverse effects of hazardous wastes. Its scope of application covers a wide range of wastes defined as "hazardous wastes" based on their origin and/or composition and their characteristics, as well as two types of wastes defined as "other wastes" such as waste containing heavy metals such as Lead (Pb) and Mercury (Hg) and wastes from hospitals which contains contaminants.

Environmental Legislation and Policies in Sri Lanka

The Constitution of the Democratic Socialist Republic of Sri Lanka has provision for the protection, preservation and improvement of the environment. The government of Sri Lanka has formulated many legislation and policies focused on environmental conservation and most of them are revised from time to time to accommodate updates. Legislation is a set of regulations for which stakeholders is given a penalty when it is violated. Policy is a set of practices that is followed by stakeholders and there is no such penalty imposed when it is not practiced.

Fauna and Flora Protection Ordinance and National Environmental Act (NEA) are Some examples for key legislation on environment conservation.

Fauna and Flora Protection Ordinance (FFPO)

The Ordinance, No.2 of 1937, and subsequent amendments, make provisions for the protection of wildlife and flora in the country. The authority responsible for enforcing this law is the Department of Wildlife Conservation (DWLC). Operation and management of National Parks, Strict Natural Reserves, Jungle Corridors and Sanctuaries are conducted under FFPO.

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Notes:

This is to acknowledge that some of the diagrams used in this book have been taken from various electronic sources using internet . This book is not published to make profit and sold only to cover cost.

The resource book is prepared according to the subject content and learning outcomes of the G.C.E. (A.L) Biology new syllabus which is implemented from 2017.

The content of this Resource book declares the limitation of the G.C.E. (A.L) Biology new syllabus which is implemented from 2017.