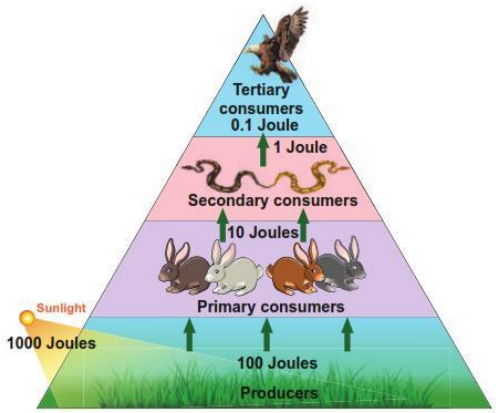


Figure 7.10: Pyramids of energy(Kcal/unit area/unit time) in any ecosystem

7.2.8 Decomposition:

Decomposition is a process in which the detritus (dead plants, animals and their excreta) are breakdown in to simple organic matter by the decomposers. It is an essential process for recycling and balancing the nutrient pool in an ecosystem.

Nature of decomposition

The process of decomposition varies based on the nature of the organic compounds, i.e., some of the compounds like carbohydrate, fat and protein are decomposed rapidly than the cellulose, lignin, chitin, hair and bone.

Mechanism of decomposition

Decomposition is a step wise process of degradation mediated by enzymatic reactions. Detritus acts as a raw material for decomposition. It occurs in the following steps.

a. **Fragmentation** - The breaking down of detritus into smaller particles by detritivores like bacteria, fungi and earth worm is known as **fragmentation**. These detritivores secrete certain substances to enhance the fragmentation process and increase the surface area of detritus particles.

b. **Catabolism** - The decomposers produce some extracellular enzymes in their surroundings to break down complex organic and inorganic compounds in to simpler ones. This is called **catabolism**

c. **Leaching or Eluviation** - The movement of decomposed, water soluble organic and inorganic compounds from the surface to the lower layer of soil or the carrying away

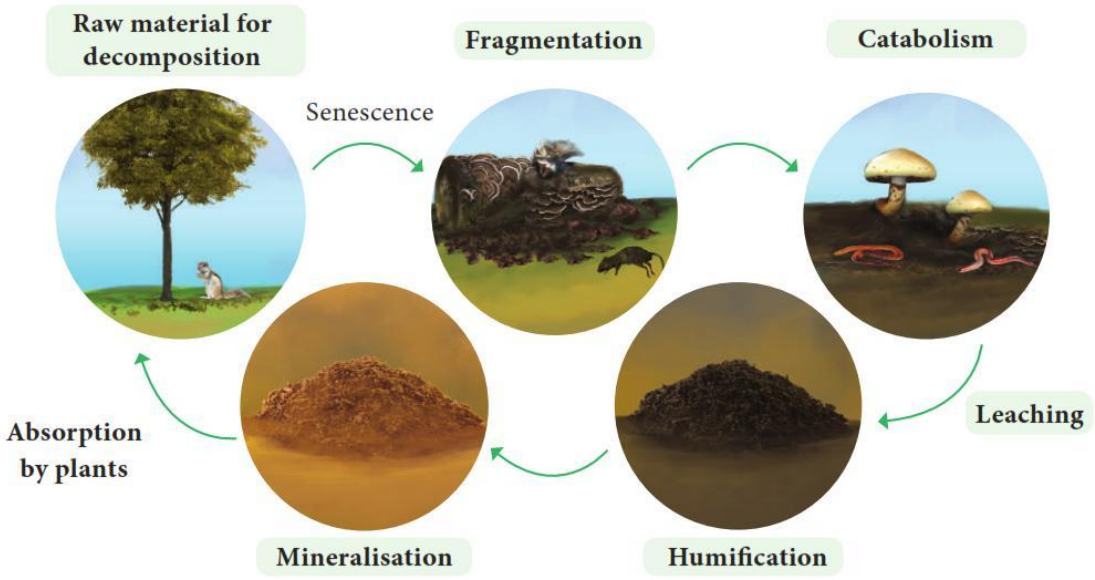


Figure 7.11: Diagrammatic representation – Process of decomposition and cycling of nutrients.

of the same by water is called **leaching** or **eluviation**.

d. **Humification** - It is a process by which simplified detritus is changed into dark coloured amorphous substance called **humus**. It is highly resistant to microbial action, therefore decomposition is very slow. It is the reservoir of nutrients.

e. **Mineralisation** - Some microbes are involved in the release of inorganic nutrients from the humus of the soil, such process is called **mineralisation**.

Factors affecting decomposition

Decomposition is affected by climatic factors like temperature, soil moisture, soil pH ,oxygen and also the chemical quality of detritus.

7.2.9 Biogeochemical cycle (Nutrient cycle)

Exchange of nutrients between organisms and their environment is one of the essential aspects of an ecosystem. All organisms require nutrients for their growth, development, maintenance and reproduction. Circulation of nutrients within the ecosystem or biosphere is known as **biogeochemical cycles** and also called as 'cycling of materials.' There are two basic types,

1. **Gaseous cycle** – It includes atmospheric Oxygen, Carbon and Nitrogen cycles.
2. **Sedimentary cycle** – It includes the cycles of Phosphorus, Sulphur and Calcium - Which are present as sediments of earth.

Many of the cycles mentioned above are studied by you in previous classes. Therefore, in this chapter, only the carbon and phosphorous cycles are explained.

Carbon cycle

The circulation of carbon between organisms and environment is known as the **carbon cycle**. Carbon is an inevitable part of all biomolecules and is substantially impacted by the change in global climate. Cycling of carbon between organisms and atmosphere is a consequence of two reciprocal processes of photosynthesis and respiration. The relesing of carbon in the atmosphere increases due to burning of fossile fules, deforestration, forest fire, volcanic eruption and decomposition of dead organic matters. The details of carbon cycle are given in the figure.

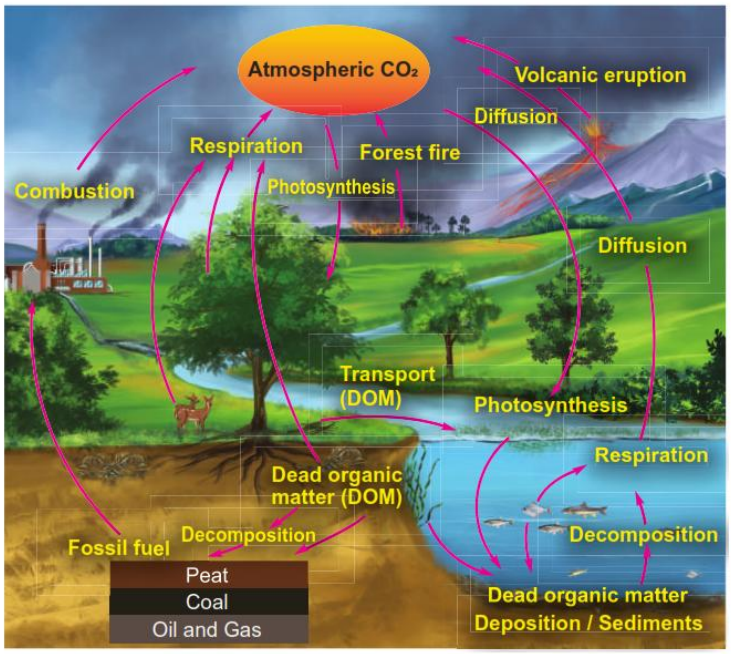


Figure 7.12: Diagrammatic Sketch showing Carbon cycle

Phosphorus cycle

It is a type of sedimentary cycle. Already we know that phosphorus is found in the biomolecules like DNA, RNA, ATP, NADP and phospholipid molecules of living organisms. Phosphorus is not abundant in the biosphere, whereas a bulk quantity of phosphorus is present in rock deposits, marine sediments and guano. It is released from these deposits by weathering

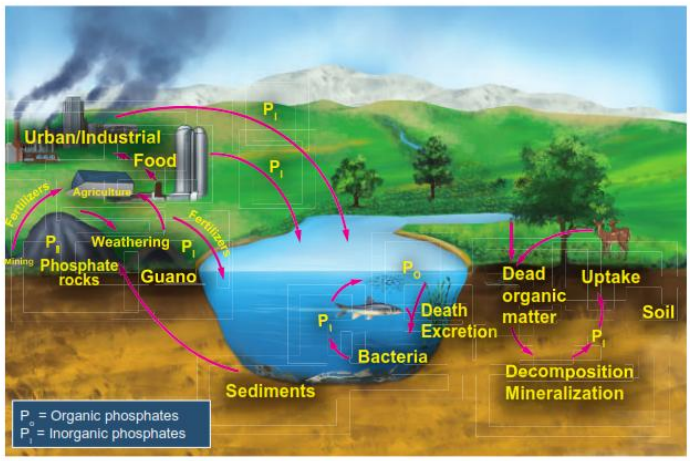


Figure 7.13: Diagrammatic sketch showing Phosphorous cycle

process. After that, it circulates in lithosphere as well as hydrosphere. The producers absorb phosphorus in the form of phosphate ions, and then it is transferred to each trophic level of food chain through food. Again death of the organisms and degradation by the action of decomposers, the phosphorus is released back into the lithosphere and hydrosphere to maintain phosphorus cycle.

7.2.10 Types of ecosystem

Biosphere consists of different types of ecosystems, which are as follows:

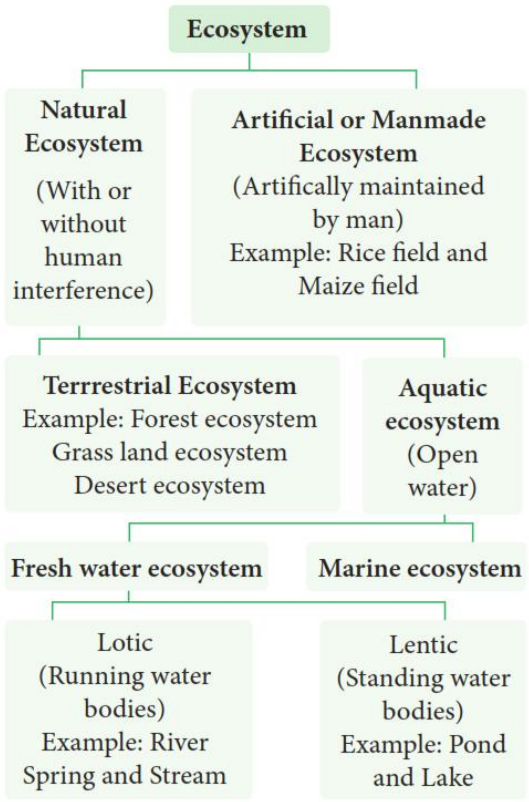


Figure 7.14: Types of Ecosystem

Though there are many types of ecosystems as charted above. Only the pond ecosystem is detailed below.

Structure of Pond ecosystem

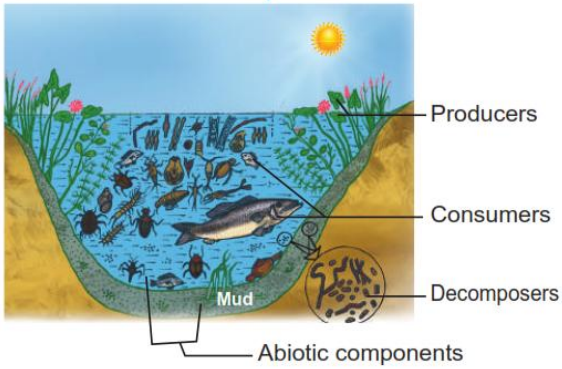


Figure 7.15: Diagram shows structure of pond ecosystem with abiotic and biotic components.

It is a classical example for natural, aquatic, freshwater, lentic type of ecosystem. It helps us to understand the structure and function of an ecosystem. When rain water gathers in a shallow area, gradually over a period of time, different kinds of organisms (microbes, plants, animals) become part of this ecosystem. This pond ecosystem is a self sustaining and self regulatory fresh water ecosystem, which shows a complex interaction between the abiotic and biotic components in it.

Activity

Collect few living and nonliving components from any water body found near by.

Abiotic components

A pond ecosystem consists of dissolved inorganic (CO_2, O_2, Ca, N, Phosphate) and organic substances (amino acids and humic acid) formed from the dead organic matter. The function of pond ecosystem is regulated by few factors like the amount of light, temperature, pH value of water and other climatic conditions.

Biotic components

They constitute the producers, variety of consumers and decomposers (microorganisms).

a. Producers

A variety of phytoplanktons like *Oscillatoria, Anabaena, Eudorina, Volvox* and *Diatoms.* Filamentous algae such as *Ulothrix, Spirogyra, Cladophora* and *Oedogonium;* floating plants *Azolla, Salvia, Pistia, Wolffia* and *Eichhornia*; sub-merged plants *Potamogeton* and *Phragmitis*; rooted floating plants *Nymphaea* and *Nelumbo*; macrophytes like *Typha* and *Ipomoea,* constitute the major producers of a pond ecosystem.

b. Consumers

The animals represent the consumers of a pond ecosystem include zooplanktons like *Paramoecium* and *Daphnia* (primary consumers); benthos (bottom living animals) like mollusces and annelids; secondary consumers like water beetles and frogs; and tertiary consumers (carnivores) like duck , crane and some top carnivores which include large fish, hawk ,man, etc.

Sea grasses and mangroves of Estuarine and coastal ecosystems are the most efficient in carbon sequestration. Hence, these ecosystems are called as " **Blue carbon ecosystems**". They are not properly utilized and maintained all over the world although they have rich bioresources potential.

c. Decomposers

They are also called as microconsumers. They help to recycle the nutrients in the ecosystem. These are present in mud water and bottom of the ponds. Example: Bacteria and Fungi. Decomposers perform the process of decomposition in order to enrich the nutrients in the pond ecosystem.

The cycling of nutrients between abiotic and biotic components is evident in the pond ecosystem, making itself self sufficient and self regulating.

Limnology
It is the study of biological, chemical, physical and geological components of inland fresh water aquatic ecosystems (ponds, lakes, etc.).

Oceanography – It is the study of biological, chemical, physical and geological components of ocean.

Stratification of pond ecosystem

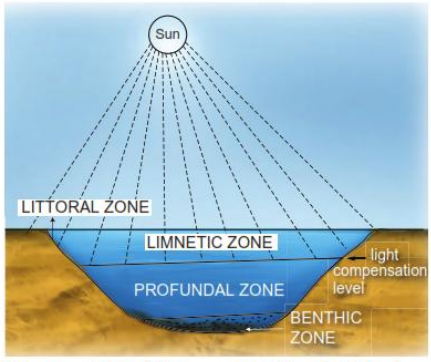


Figure 7.16: Diagrammatic sketch shows stratification of Pond ecosystem

Based on the factors like distance from the shore, penetration of light, depth of water, types of plants and animals, there may be three zones, littoral, limnetic and profundal. The littoral zone, which is closest to the shore with shallow water region, allows easy penetration of light. It is warm and occupied by rooted plant

species. The limnetic zone refers the open water of the pond with an effective penetration of light and domination of planktons. The deeper region of a pond below the limnetic zone is called profundal zone with no effective light penetration and predominance of heterotrophs. The bottom zone of a pond is termed benthic and is occupied by a community of organisms called benthos (usually decomposers).The primary productivity through photosynthesis of littoral and limnetic zone is more due to greater penetration of light than the profundal zone.

7.2.11 Ecosystem services (Benefits)

Ecosystem services are defined as the benefits that people derive from nature. Robert Constanza et al (1927) stated "Ecosystem services are the benefits provided to human, through the transformation of resources (or Environmental assets including land, water, vegetation and atmosphere) into a flow of essential goods and services".

Study on ecosystem services acts as an effective tool for gaining knowledge on ecosystem benefits and their sustained use. Without such knowledge gain, the fate of any ecosystem will be at stake and the benefits they provide to us in future will become bleak.

DO YOU KNOW?

Robert Constanza and his colleagues estimated the value of global ecosystem services based on various parameters. According to them in 1997, the average global value of ecosystems services estimated was US $ 33 trillion a year. The updated estimate for the total global ecosystem services in 2011 is US $ 125 trillion / year, indicating a four-fold increase in ecosystem services from 1997 to 2011.

Mangrove ecosystem services

- Offers habitat and act as nursery for aquatic plants and animals
- Provides medicine, fuel wood and timber.
- Act as bridge between sea and rivers by balancing sedimentation and soil erosion.
- Help to reduce water force during cyclones, tsunamis and high tide periods.
- Help in wind break, O_2 production, carbon sequestration and prevents salt spray from waves.

The varieties of benefits obtained from the ecosystem are generally categorized into the following four types

Ecosystem services

Provisoning services	Cultural services	Supporting services	Regulating services
• Food, fiber and fuel	• Spiritual and religious values	• Primary production	• Invasion resistance
• Genetic resources	• Knowledge system	• Provision of habitat	• Herbivory pollination
• Bio-chemicals	• Education and inspiration	• Nutrient cycling	• Seed dispersal
• Fresh water	• Recreation and aesthetic values	• Soil formation and retention	• Climate regulation
• Medicines	• Ecotourism	• Production of atmospherc oxygen	• Pest regulation
		• Water cycling	• Disease regulation
			• Erosion regulation
			• Water purification
			• Natural hazard protection

Figure 7.17: Types of Ecosystem services

How do anthropogenic activities affect ecosystem services?

Now, we all exploit the ecosystem more than that of our needs. The **Millennium Ecosystem Assessment (2005)** found that "over the past 50 years, humans have changed the ecosystem more rapidly and extensively than in any comparable period of time in human history, largely to meet rapidly growing demands for food, fresh water, medicine, timber, fiber and fuel."

Generally the following human activities disturb or re-engineer an ecosystem every day.

- Habitat destruction
- Deforestation and over grazing
- Erosion of soils
- Introduction of non-native species
- Over harvesting of plant material
- Pollution of land, water and air
- Run off pesticides, fertilizers and animal wastes

Ecosystem resilience

Ecosystem is damaged by disturbances from fire, flood, predation, infection, drought, etc., removing a great amount of biomasss. However, ecosystem is endowed with the ability to resist the damage and recover quickly. This ability of ecosystem is called ecosystem resilience or ecosystem robustness.

How to protect the ecosystem?

It is a practice of protecting ecosystem at individual, organisational and governmental levels for the benefits of both nature and humans. Threats to ecosystems are many, like adverse human activities, global warming, pollution, etc. Hence, if we change our everyday life style, we can help to protect the planet and its ecosystem.

"If we fail to protect environment, we will fail to save posterity".

Therefore, we have to practice the following in our day today life:

- Buy and use only ecofriendly products and recycle them.
- Grow more trees
- Choose sustained farm products (vegetables, fruits, greens, etc.)
- Reduce the use of natural resources.
- Recycle the waste and reduce the amount of waste you produce.
- Reduce consumption of water and electricity.
- Reduce or eliminate the use of house-hold chemicals and pesticides.
- Maintain your cars and vehicles properly. (In order to reduce carbon emission)
- Create awareness and educate about ecosystem protection among your friends and family members and ask them to find out solution to minimise this problem.

Go green

It refers to the changing of one's lifestyle for the safety and benefits of the environments (Reduce, Reuse, Recycle)

Way to go green and save green

- Close the tap when not in use.
- Switch off the electrical gadgets when not in use.
- Never use plastics and replace them with biodegradable products
- Always use ecofriendly technology and products.

"USE ECOSYSTEM BUT DON'T LOSE ECOSYSTEM; MAKE IT SUSTAINABLE"

7.2.12 Ecosystem Management

It is a process that integrates ecological, socio economic and institutional factors into a comprehensive strategy in order to sustain and enhance the quality of the ecosystem to meet current and future needs.

Ecosystem management emphasis on human role in judicious use of ecosystem and for sustained benefits through minimal human impacts on ecosystems. Environmental degradation and biodiversity loss will result in depletion of natural resources, ultimately affecting the existence of human

"By 2025, at least 3.5 billion people, nearly 50% of the world's population are projected to face water scarcity." – IUCN.

"Forests house approximately 50% of global bio-diversity and at least 300 million people are dependent on forest's goods and services to sustain their livelihood." – IUCN

Strategy of ecosystem management

- It is used to maintain biodiversity of ecosystems.
- It helps in indicating the damaged ecosystem (Some species indicate the health of the ecosystem: such species are called a **flagship species**).
- It is used to recognize the inevitability of ecosystem change and plan accordingly.
- It is one of the tools used for achieving sustainability of ecosystem through sustainable development programme (or projects).
- It is also helpful in identifying ecosystems which are in need of rehabilitation.

LAP2JU

- It involves collaborative management with government agencies, local population, communities and NGO's.
- It is used to build the capacity of local institutions and community groups to assume responsibility for long term implementation of ecosystem management activities even after the completion of the project.

Urban ecosystem restoration model

Adayar Poonga is located in Chennai and covers an area around a total of 358 acres of Adayar creek and estuary, of which 58 acres were taken up for eco restoration under the auspices of Government of Tamil Nadu. It is maintained by Chennai Rivers Restoration Trust (CRRT).This was a dumping site previously.

Presently it has 6 species of mangroves, about 170 species of littoral and tropical dry evergreen forests (TDF) which have successfully established as a sustainable ecosystem. Restoration of plants species has brought other associated fauna such as butterflies, birds, reptiles, amphibians and other mammals of the ecosystem.

Currently Adayar Poonga functions as an environmental education Centre for school and college students and the public. The entire area stands as one of the best examples for urban eco restoration in the state of Tamil Nadu.

Adayar Poonga

7.3 Plant Succession

We very often see that forests and lands in our areas are drastically affected by natural calamities (Flood, earthquake) and anthropogenic activities (Fire, over grazing, cutting of trees). Due to these reasons all plants of an area are destroyed and the areas become nude. When we observe this area, over a period of a time we can see that it will be gradually covered by plant community again and become fertile. Such successive replacement of one type of plant community by the other of the same area/ place is known as plant **succession**. The first invaded plants in a barren area are called **pioneers**. On the other hand, a series of transitional developments of plant communities one after another in a given area are called **seral communities**. At the end a final stage and a final plant community gets established which are called as climax and climax community respectively.

7.3.1 Characteristics of ecological succession

- It is a systematic process which causes changes in specific structure of plant community.
- It is resultant of changes of abiotic and biotic factors.
- It transforms unstable community into a stable community.
- Gradual progression in species diversity, total biomass, niche specialisation, and humus content of soil takes place.
- It progresses from simple food chain to complex food web.
- It modifies the lower and simple life form to the higher life forms.
- It creates inter-dependence of plants and animals.

7.3.2 Types of succession

The various types of succession have been classified in different ways on the basis of different aspects. These are as follows:

1. Primary succession - The development of plant community in a barren area where no community existed before is called primary succession. The plants which colonize first in a barren area is called **pioneer species** or **primary community** or **primary colonies**. Generally, Primary succession takes a very long time for the occurrence in any region.

Example: Microbes, Lichen, Mosses.

2. Secondary succession - The development of a plant community in an area where an already developed community has been destroyed by some natural disturbance (Fire, flood, human activity) is known as **secondary succession**.

	Primary succession	Secondary succession
1	Developing in an barren area	Developing in disturbed area
2	Initiated due to a biological or any other external factors	Starts due to external factors only
3	No soil, while primary succession starts	It starts where soil covers is already present
4	Pioneer species come from outside environment	Pioneer species develop from existing environment
5	It takes more time to complete	It takes comparatively less time to complete

Table 1: Differences between primary and secondary succession

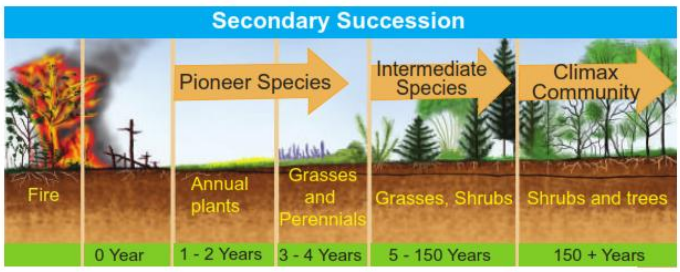


Figure 7.18: Diagrammatic representation of secondary succession

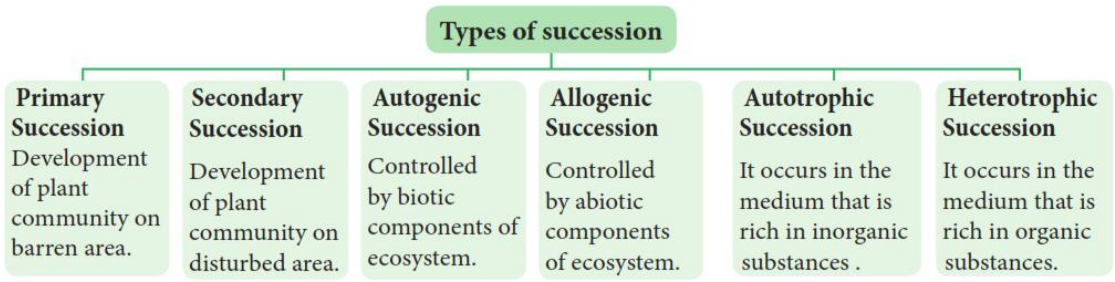


Figure 7.19: Types of succession

Generally, This succession takes less time than the time taken for primary succession.

Example: The forest destroyed by fire and excessive lumbering may be re-occupied by herbs over period of times.

3. Autogenic succession

Autogenic succession occurs as a result of biotic factors. The vegetation reacts with its environment and modifies its own environment causing its own replacement by new communities. This is known as **autogenic succession**.

Example: In forest ecosystem, the larger trees produce broader leaves providing shade to the forest floor area. It affects the shrubs and herbs which require more light (heliophytes) but supports the shade tolerant species (sciophytes) to grow well.

4. Allogenic succession

Allogeneic succession occurs as a result of abiotic factors. The replacement of existing community is caused by other external factors (soil erosion, leaching, etc.,) and not by existing organisms.

Example: In a forest ecosystem soil erosion and leaching alter the nutrient value of the soil leading to the change of vegetation in that area.

5. Autotrophic succession

If the autotrophic organisms like green plants are dominant during the early stages of succession it is called **autotrophic succession**, this occurs in the habitat which is rich in inorganic substances. Since, green plants dominate in the beginning of this succession, there is a gradual increase in organic matter and subsequently the energy flow in the ecosystem.

LQ7WL6

6. Heterotrophic succession

If heterotrophic organisms like bacteria, fungi, actinomycetes, and animals are dominant during the early stages of succession it is called **heterotrophic succession**. Such a succession takes place in organic habitats. Since heterotrophs dominate in the beginning of such succession, there will be a gradual decrease in the energy content.

7.3.3 Classification of plant succession

Detailed study of Hydrosere and Lithosere are discussed below:

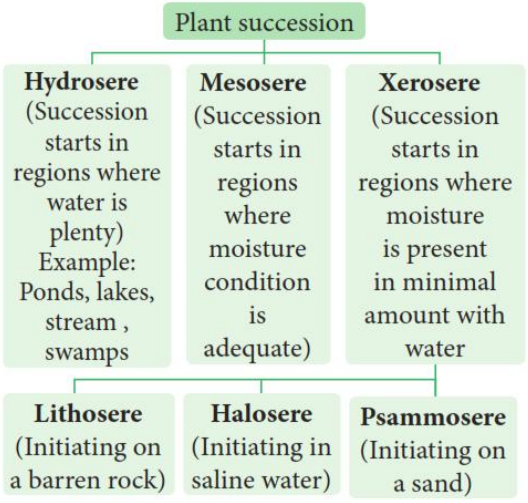


Figure 7.20: Classification of plant succession

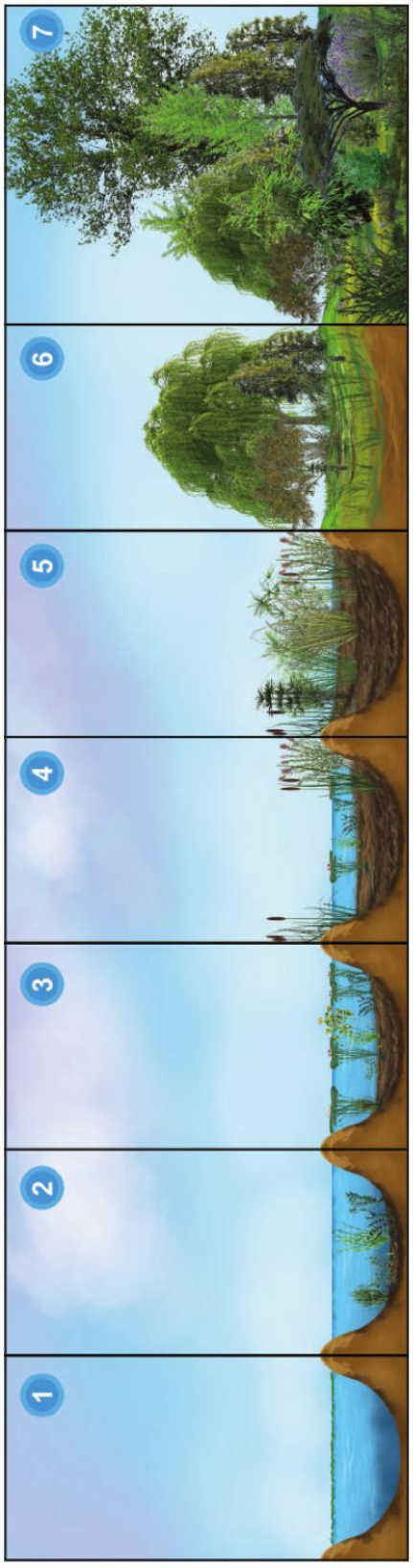


Figure 7.21: Diagrammatic representation shows different stages of hydrosere.

Hydrosere

The succession in a freshwater ecosystem is also referred to as hydrosere. Succession in a pond, begins with colonization of the pioneers like phytoplankton and finally ends with the formation of climax community like forest stage. It includes the following stages Fig 7.21.

1. Phytoplankton stage - It is the first stage of succession consisting of the pioneer community like blue green algae, green algae, diatoms, bacteria, etc., The colonization of these organisms enrich the amount of organic matter and nutrients of pond due to their life activities and death. This favors the development of the next seral stages.

2. Submerged plant stage - As the result of death and decomposition of planktons, silt brought from land by rain water, lead to a loose mud formation at the bottom of the pond. Hence, the rooted submerged hydrophytes begin to appear on the new substratum. Example: *Chara, Utricularia, Vallisneria* and *Hydrilla* etc. The death and decay of these plants will build up the substratum of pond to become shallow. Therefore, this habitat now replaces another group of plants which are of floating type.

3. Submerged free floating stage - During this stage, the depth of the pond will become almost 2-5 feet. Hence, the rooted hydrophytic plants and with floating large leaves start colonising the pond. Example: Rooted floating plants like *Nelumbo, Nymphaea* and *Trapa*. Some free floating species like *Azolla, Lemna, Wolffia* and *Pistia* are also present in this stage. By death and decomposition of these plants, further the pond becomes more shallow. Due to this reason, floating plant species is gradually replaced by another species which makes new seral stage.

4. Reed-swamp stage - It is also called an amphibious stage. During this stage, rooted floating plants are replaced by plants which can live successfully in aquatic as well as aerial

environment. Example: *Typha, Phragmites, Sagittaria* and *Scirpus* etc. At the end of this stage, water level is very much reduced, making it unsuitable for the continuous growth of amphibious plants.

5. Marsh meadow stage - When the pond becomes swallowed due to decreasing water level, species of Cyperaceae and Poaceae such as *Carex, Juncus, Cyperus* and *Eleocharis* colonise the area. They form a mat-like vegetation with the help of their much branched root system. This leads to an absorption and loss of large quantity of water. At the end of this stage, the soil becomes dry and the marshy vegetation disappears gradually and leads to shurb stage.

6. Shrub stage - As the disappearance of marshy vegetation continues, soil becomes dry. Hence, these areas are now invaded by terrestrial plants like shrubs (*Salix* and *Cornus*) and trees (*Populus* and *Alnus*). These plants absorb large quantity of water and make the habitat dry. Further, the accumulation of humus with a rich flora of microorganisms produce minerals in the soil, ultimately favouring the arrival of new tree species in the area.

7. Forest stage - It is the climax community of hydrosere. A variety of trees invade the area and develop any one of the diverse type of vegetation. Example:Temperate mixed forest (*Ulmus,Acer* and *Quercus*), Tropical rain forest (*Artocarpus* and *Cinnamomum*) and Tropical deciduous forest (*Bamboo* and *Tectona*).

In the 7 stages of hydrosere succession, stage1 is occupied by pioneer community, while the stage 7 is occupied by the climax community. The stages 2 to 6 are occupied by seral communities.

7.3.4 Significance of Plant Succession

- Succession is a dynamic process. Hence an ecologist can access and study the seral stages of a plant community found in a particular area.
- The knowledge of ecological succession helps to understand the controlled growth of one or more species in a forest.
- Utilizing the knowledge of succession, even dams can be protected by preventing siltation.
- It gives information about the techniques to be used during reforestation and afforestation.
- It helps in the maintenance of pastures.
- Plant succession helps to maintain species diversity in an ecosystem.
- Patterns of diversity during succession are influenced by resource availability and disturbance by various factors.
- Primary succession involves the colonization of habitat of an area devoid of life.
- Secondary succession involves the reestablishment of a plant community in disturbed area or habitat.
- Forests and vegetation that we come across all over the world are the result of plant succession.

Summary

The interaction between biotic and abiotic components in an environment is called ecosystem. Autotrophs and heterotrophs are the producers and consumers respectively. The function of ecosystem refers to creation of energy, flow of energy and cycling of nutrients. The amount of light available for photosynthesis is called Photo synthetically Active Radiation . It is essential for increase in the productivity of ecosystem. The rate of biomass production per unit area /time is called productivity. It is classified as primary productivity, secondary productivity and community productivity. The transfer of energy in an ecosystem can be termed as energy flow. It is explained through the food chain, food web , ecological pyramids (pyramid of number, biomass and energy) and biogeochemical cycle. Cycling of nutrients between abiotic and biotic components is evident in the pond ecosystem,

making itself self sufficient and self regulating Ecosystem protected for the welfare of posterity is called ecosystem management.

Successive replacement of one type of plant community by the other of the same area/ place is known as plant succession. The first invaded plants in a barren (nude) area are called pioneers (pioneers communities). On the other hand, a series of transitional developments of plant communities one after another in a given area are called seral communities. Succession is classified as primary succession, secondary succession, autogenic succession, allogeneic succession, autotrophic succession and heterotrophic succession. Plant succession is classified in to hydrosere (Initiating on a water bodies) ,Mesosere and xerosere. Further xerosere is subdivided in to Lithosere (Initiating on a barren rock), Halosere and Pasmmosere.

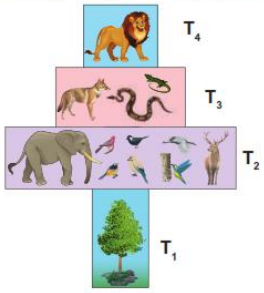
Evaluation

I Choose the most suitable answer from the given four alternatives and write the option code and the corresponding answer.

M5QRMH

1. Which of the following is not a abiotic component of the ecosystem?
   a) Bacteria
   b) Humus
   c) Organic compounds
   d) Inorganic compounds
2. Which of the following is / are not a natural ecosystem?
   a) Forest ecosystem
   b) Rice field
   c) Grassland ecosystem
   d) Desert ecosystem
3. Pond is a type of
   a) forest ecosystem
   b) grassland ecosystem
   c) marine ecosystem
   d) fresh water ecosystem
4. Pond ecosystem is
   a) not self sufficient and self regulating
   b) partially self sufficient and self regulating
   c) self sufficient and not self regulating
   d) self sufficient and self regulating
5. Profundal zone is predominated by heterotrophs in a pond ecosystem, because of
   a) with effective light penetration
   b) no effective light penetration
   c) complete absence of light
   d) a and b
6. Solar energy used by green plants for photosynthesis is only
   a) 2 – 8% b) 2 – 10%
   c) 3 – 10% d) 2 – 9%
7. Which of the following ecosystem has the highest primary productivity?
   a) Pond ecosystem
   b) Lake ecosystem
   c) Grassland ecosystem
   d) Forest ecosystem
8. Ecosystem consists of
   a) decomposers b) producers
   c) consumers d) all of the above
9. Which one is in descending order of a food chain
   a) Producers → Secondary consumers → Primary consumers → Tertiary consumers
   b) Tertiary consumers → Primary consumers → Secondary consumers → Producers
   c) Tertiary consumers → Secondary consumers → Primary consumers → Producers
   d) Tertiary consumers → Producers → Primary consumers → Secondary consumers
10. Significance of food web is / are
    a) it does not maintain stability in nature
    b) it shows patterns of energy transfer
    c) it explains species interaction
    d) b and c

11. The following diagram represents



a) pyramid of number in a grassland ecosystem
b) pyramid of number in a pond ecosystem
c) pyramid of number in a forest ecosystem
d) pyramid of biomass in a pond ecosystem

12. Which of the following is / are not the mechanism of decomposition
a) Eluviation b) Catabolism
c) Anabolism d) Fragmentation

13. Which of the following is not a sedimentary cycle
a) Nitrogen cycle b) Phosphorous cycle
c) Sulphur cycle d) Calcium cycle

14. Which of the following are not regulating services of ecosystem services
i) Genetic resources
ii) Recreation and aesthetic values
iii) Invasion resistance
iv) Climatic regulation
a) i and iii b) ii and iv
c) i and ii d) i and iv

15. Productivity of profundal zone will be low. Why?

16. Discuss the gross primary productivity is more efficient than net primary productivity.

17. Pyramid of energy is always upright. Give reasons

18. What will happen if all producers are removed from ecosystem?

19. Construct the food chain with the following data.
Hawk, plants, frog, snake, grasshopper.

20. Name of the food chain which is generally present in all type of ecosystem. Explain and write their significance.

21. Shape of pyramid in a particular ecosystem is always different in shape. Explain with example.

22. Generally human activities are against to the ecosystem, where as you a student how will you help to protect ecosystem?

23. Generally in summer the forest are affected by natural fire. Over a period of time it recovers itself by the process of successions . Find out the types of succession and explain.

24. Draw a pyramid from following details and explain in brief.
Quantities of organisms are given-Hawks-50, plants-1000.rabbit and mouse-250 +250, pythons and lizard- 100 + 50 respectively.

25. Various stages of succession are given bellow. From that rearrange them accordingly. Find out the type of succession and explain in detail.
Reed-swamp stage, phytoplankton stage, shrub stage, submerged plant stage, forest stage, submerged free floating stage, marsh medow stage.

Glossary

Ecosystem: Study of interaction between living and non-living components

Standing quality: Total inorganic substances presents in any ecosystem at a given time and given area

Standing crops: Amount of living material present in a population at any time.

Biomass: Can be measured as fresh weight or dry weight of organisms

Benthic: Bottom zone of the pond

Trophic: Refers to the position of organisms in food chain

Omnivores: Those eats both plants and animals

Food chain: Refers movement of energy from producers up to top carnivores

Food web: Interlocking pattern of food chain

Pyramid of number: Refers number of organisms in a successive trophic level

Pyramid of biomass: Refers to quantitative relationship of the standing crops

Pyramid of energy: Refers transformation of energy at successive trophic levels

Ten per cent law: refers only 10 per cent of energy is stored in each successive trophic levels

Bio geo chemical cycle: Exchange of nutrients between organisms and environments

Carbon cycle: Circulation of carbon among organisms and environments

Guano: It is a accumulated excrement of sea birds and bats.

Phosphorus cycle: Circulation of Phosphorus among organisms and environments

Succession: Successive replacement of one type of plant communities by other on barren or disturbed area.

Pioneers: Invaded plants on barren area

Primary succession: Plants colonising on barren area

Secondary succession: Plants colonising on disturbed area.

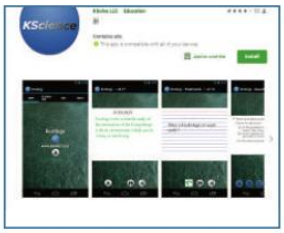
Climax communities: Final establishment of plant communities which are not replaced by others.

ICT Corner

ECO SYSTEM

B266_12_BOT_EM

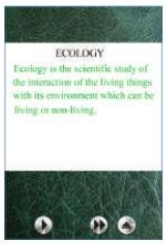
Let us know about the **Ecosystem** in detail through this activity.



Steps

- Type the URL or scan the QR code to open the activity page then Introduction page will open.
- Click on the Learn icon in the introduction page to know in detail.
- Click on the Flashcards icon in the introduction page to know about the topics easily.
- Click on the Test icon to write a quiz test finally it displays the marks we scored.

Step 1



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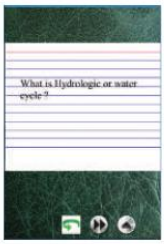

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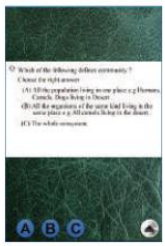

Step 4

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* Pictures are indicative only

Chapter

8

Unit IX - Plant Ecology

Environmental Issues

Learning Objectives

Learning objectives

The learner will be able to,

- Understand the importance of growing more plants to mitigate the environmental problems.
- Distinguish between the importance and conservation of endemic and endangered species.
- Appreciate the use of technologies for agriculture and forestry.
- Participate in community activities to improve environmental conditions.
- Develop methods in conservation of water and plants for sustainable development.
- Get acquainted with satellite technology and utilising it in our daily life needs

Chapter outline

MZIKNH

After understanding the structure and functions of major ecosystems of the world, now student community should observe and understand environmental problems of their surroundings at local, national and international level.

Now we are going to understand some of the environmental issues such as

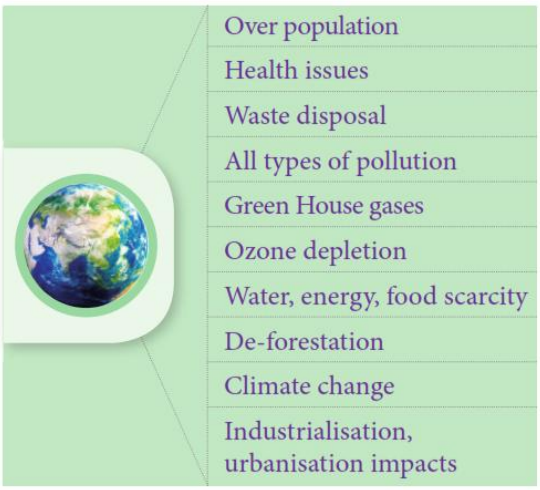

Figure 8.1: Environmental issues

Environmental issues are the problems and harmful effects created by human's unmindful activity and over utilisation of valuable resources obtained from the nature (environment). Student should understand not only the environmental issues we are facing now, but also find solutions to rectify or reduce these problems.

Countries of the whole world agree that something needs to be done about these important environmental issues. Many global summits, conferences and conventions are regularly conducted by the United Nations and many steps are taken to minimise human-induced issues by signing agreements with around 150 countries.

Activity

Students may form 'ECOGROUPS' and discuss eco-issues of their premises and find solutions to the existing problems like, litter disposal, water stagnation, health and hygiene, greening the campus and its maintenance.

Drastic increase in population resulted in demand for more productivity of food materials, fibres, fuels which led to many environmental issues in agriculture, land use modifications resulting in loss of biodiversity, land degradation, reduction in fresh water availability and also resulting in man-made global warming by green house gases even altering climatic conditions.

8.1 Green House effect and Global Warming

Green House Effect is a process by which radiant heat from the sun is captured by gases in the atmosphere that increase the temperature of the earth ultimately. The gases that capture heat are called **Green House Gases** which include carbon dioxide (CO_2), methane (CH_4), Nitrous Oxide (N_2O) and a variety of manufactured chemicals like chlorofluorocarbon (CFC). Increase in greenhouse gases lead to irreversible changes in major ecosystems and climate patterns. For example, coral ecosystem is affected by increase in temperature, especially **coral bleaching** observed in Gulf of Mannar, Tamil Nadu.

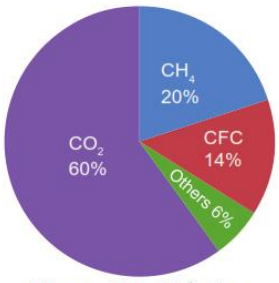

Figure 8.2: Relative contribution of green house gases

Human activities lead to produce the green house effect by

- Burning fossil fuels, which releases CO_2 and CH_4
- Way of Agriculture and animal husbandry practices
- Electrical gadgets like refrigerator and air conditioners release chloro fluoro carbons
- The fertilizers used in Agriculture which release N_2O
- The emissions from automobiles.

The increase in mean global temperature (highest in 4000 years) due to increased concentration of green house gases is called **global warming.**

One of the reasons for this is over population which creates growing need for food, fibre and fuel and considered to be the major cause of global warming.

Clouds and Dust particles can also produce Green House effect. That is why clouds, dusts and humid nights are warmer than clear dust free dry nights.

8.1.1. Effects of Global Warming

- Rise in global temperature which causes sea levels to rise as polar ice caps and glaciers begin to melt causing submergence of many coastal cities in many parts of the world.
- There will be a drastic change in weather patterns bringing more floods or droughts in some areas.
- Biological diversity may get modified, some species ranges get redefined. Tropics and sub-tropics may face the problem of decreased food production.

8.1.2. Sources of Green House Gases Emission (Natural and Anthropogenic)

CO_2 (Carbon dioxide)

- Coal based power plants, by the burning of fossil fuels for electricity generation.
- Combustion of fuels in the engines of automobiles, commercial vehicles and air planes contribute the most of global warming.
- Agricultural practices like stubble burning result in emission of CO_2.
- Natural from organic matter, volcanoes, warm oceans and sediments.

Methane

Methane is 20 times as effective as CO_2 at trapping heat in the atomosphere. Its sources are attributed paddy cultivation, cattle rearing, bacteria in water bodies, fossil fuel production, ocean, non-wetland soils and forest / wild fires.

N_2O (Nitrous oxide)

It is naturally produced in Oceans from biological sources of soil and water due to microbial actions and rainforests. Man-made sources include nylon and nitric acid production, use of fertilizers in agriculture, manures cars with catalytic converter and burning of organic matter.

Global Warming Effects on Plants

- Low agricultural productivity in tropics
- Frequent heat waves (Weeds, pests, fungi need warmer temperature)
- Increase of vectors and epidemics
- Strong storms and intense flood damage
- Water crisis and decreased irrigation
- Change in flowering seasons and pollinators
- Change in Species distributional ranges
- Species extinction

8.1.3 Strategies to deal with Global Warming

- Increasing the vegetation cover, grow more trees
- Reducing the use of fossil fuels and green house gases
- Developing alternate renewable sources of energy
- Minimising uses of nitrogeneous fertilizers, and aerosols.

8.1.4. Ozone depletion

Ozone layer is a region of Earth's stratosphere that absorbs most of the Sun's ultra violet radiation. The ozone layer is also called as the **ozone shield** and it acts as a protective shield, cutting the ultra-violet radiation emitted by the sun.

Just above the atmosphere there are two layers namely troposphere (the lower layer) and stratosphere (the upper layer). The ozone layer of the troposphere is called **bad ozone** and the ozone layer of stratosphere is known as **good ozone** because this layer acts as a shield for absorbing the UV radiations coming from the sun which is harmful for living organisms

Ozone is a colourless gas, reacts readily with air pollutants and cause rubber to crack, hurt plant life, damages lung tissues. But ozone absorbs harmful ultra violet β (uv-β) and UV – α radiation from sunlight.

What is Dobson Unit? DU is the unit of measurement for total ozone. One DU (0.001 atm. cm) is the number of molecules of ozone that would be required to create a layer of pure ozone 0.01 millimetre thick at a temperature of 0° C and a pressure of 1 atmosphere (atm = the air pressure at the surface of earth). Total ozone layer over the earth surface is 0.3 centrimetres (3 mm) thick and is written as 300 DU.

The false colour view of total ozone - The purple and blue colours are where there is the least ozone, and the yellows and reds are where there is more ozone.

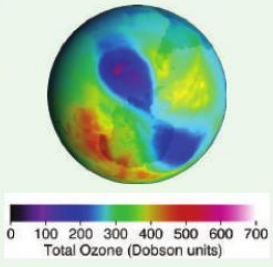

Figure 8.3: The false colour view of total ozone

causing DNA damage. The thickness of the ozone column of air from the ground to the top of the atmosphere is measured in terms of **Dobson Units**.

The ozone shield is being damaged by chemicals released on the Earth's surface notably the chlorofluorocarbons widely used in refrigeration, aerosols, chemicals used as cleaners in many industries. The decline in the thickness of the ozone layer over restricted area is called **Ozone hole.**

September 16 is WORLD OZONE DAY

Ozone depletion in the stratosphere results in more UV radiations especially UV B radiations (shortwaves). UV B radiation destroys biomolecules (skin ageing) and damages living tissues. UV – C is the most damaging type of UV radiation, but it is completely filtered by the atmosphere (ozone layer). UV – a contribute 95% of UV radiation which causes tanning burning of skin and enhancing skin cancer. Hence the uniform ozone layer is critical for the wellbeing of life on earth.

During 1970's research findings indicated that man-made chlorofluorocarbons (CFC) reduce and convert ozone molecules in the atmosphere. The threats associated with reduced ozone pushed the issue to the forefront of global climate issues and gained promotion through organisation such as World Meterological Organisation and the United Nations. The Vienna Convention was agreed upon at the Vienna conference of 1985 but entered into force in 1988 provided the frameworks necessary to create regulative measures in the form of the Montreal protocol. The International treaty called the **Montreal Protocol** (1987) was held in Canada on **substances that deplete ozone layer** and the main goal of it is gradually eliminating the production and consumption of ozone depleting substances and to limit their damage on the Earth's ozone layer.

Clean Development Mechanism (CDM) is defined in the **Kyoto protocol** (2007) which provides project based mechanisms with two objectives to prevent dangerous climate change and to reduce green house gas emissions. CDM projects helps the countries to reduce or limit emission and stimulate sustainable development.

An example for CDM project activity, is replacement of conventional electrification projects with solar panels or other energy efficient boilers. Such projects can earn Certified Emission Reduction (CER) with credits / scores, each equivalent to one tonne of CO_2, which can be counted towards meeting Kyoto targets.

Plant indicators

The presence or absence of certain plants indicate the state of environment by their response. The plant species or plant community acts as a measure of environmental conditions, it is referred as biological indicators or phytoindicators or plant indicators.

Examples

	Plants	Indicator for
1	*Lichens, Ficus, Pinus,* Rose	SO_2 pollution
2.	*Petunia, Chrysanthemum*	Nitrate
3.	*Gladiolus*	Flouride pollution
4.	*Robinia pseudoacacia (Black locust tree)*	Indicator of heavy metal contamination

8.1.5 Effects of Ozone depletion

The main ozone depletion effects are:

- Increases the incidence of cataract, throat and lung irritation and aggravation of asthma or emphysema, skin cancer and diminishing the functioning of immune system in human beings.
- Juvenile mortality of animals.
- Increased incidence of mutations.

- In plants, photosynthetic chemicals will be affected and therefore photosynthesis will be inhibited. Decreased photosynthesis will result in increased atmospheric CO_2 resulting in global warming and also shortage of food leading to food crisis.
- Increase in temperature changes the climate and rainfall pattern which may result in flood / drought, sea water rise, imbalance in ecosystems affecting flora and fauna.

8.2 Forestry

8.2.1 Agro forestry

Agroforestry is an integration of trees, crops and livestock on the same plot of land. The main objective is on the interaction among them . Example: intercropping of two or more crops between different species of trees and shrubs, which results in higher yielding and reducing the operation costs. This intentional combination of agriculture and forestry has varied benefits including increased bio-diversity and reduced erosion.

Some of the major species cultivated in commercial Agroforestry include *Casuarina, Eucalyptus*, Malai Vembu, Teak and Kadambu trees which were among the 20 species identified as commercial timber. They are of great importance to wood-based industries.

Benefits of agroforestry

- It is an answer to the problem of soil and water conservation and also to stabilise the soil (salinity and water table) reduce landslide and water run-off problem.
- Nutrient cycling between species improves and organic matter is maintained.
- Trees provide micro climate for crops and maintain O_2 – CO_2 balanced, atmospheric temperature and relative humidity.
- Suitable for dry land where rainfall is minimum and hence it is a good system for alternate land use pattern.
- Multipurpose tree varieties like *Acacia* are used for wood pulp, tanning, paper and firewood industries.
- Agro-forestry is recommended for the following purposes. It can be used as Farm Forestry for the extension of forests, mixed forestry, shelter belts and linear strip plantation.

Rehabilitation of degraded forests and recreation forestry

The production of woody plants combined with pasture is referred to **silvopasture** system. The trees and shrubs may be used primarily to produce fodder for livestock or they may be grown for timber, fuel wood and fruit or to improve the soil.

This system is classified into following categories.

i. **Protein Bank:** In this various multipurpose trees are planted in and around farm lands and range lands mainly for fodder production.

   Example: *Acacia nilotica, Albizzia lebbek, Azadirachta indica, Gliricidia sepium, Sesbania grandiflora.*

ii. **Livefence of fodder trees and hedges:** Various fodder trees and hedges are planted as live fence to protect the property from stray animals or other biotic influences.

   Example: *Gliricidia sepium, Sesbania grandiflora, Erythrina* spp., *Acacia* spp..

8.2.2 Social forestry

It refers to the sustainable management of forests by local communities with a goal of climate carbon sequestration, change mitigation, depollution, deforestation, forest restoration and providing indirect employment opportunity for the youth. Social forestry refers to the **management of forests and afforestation on barren lands** with the purpose of helping the environmental, social and rural development and benefits. Forestry programme is done for the benefit of people and participation of

the people. Trees grown outside forests by government and public organisation reduce the pressure on forests.

In order to encourage tree cultivation outside forests, **Tree cultivation in Private Lands** was implemented in the state from 2007-08 to 2011-12. It was implemented by carrying out block planting and inter-crop planting with profitable tree species like Teak, *Casuarina*, *Ailanthus*, Silver Oak, etc. in the farming lands and by a free supply of profitable tree species for planting in the bunds. The **Tank foreshore plantations** have been a major source of firewood in Tamil Nadu. The 32 **Forestry extension centres** provide technical support for tree growing in rural areas in Tamil Nadu. These centres provide quality tree seedlings like thorn / thornless bamboo, *casuarinas*, teak, neem, *Melia dubia*, grafted tamarind and nelli, etc. in private lands and creating awareness among students by training / camps.

8.2.3. Major activities of forestry extension centres

- Training on tree growing methods
- Publicity and propaganda regarding tree growing
- Formation of demonstration plots
- Raising and supply of seedlings on subsidy
- Awareness creation among school children and youth about the importance of forests through training and camps.

8.3 Deforestation

Deforestation is one of the major contributors to enhance green house effect and global warming. The conversion of forested area into a non-forested area is known as deforestation. Forests provide us many benefits including goods such as timber, paper, medicine and industrial products. The causes are

- The conversion of forests into agricultural plantation and livestock ranching is a major cause of deforestation.
- Logging for timber
- Developmental activities like road construction, electric tower lines and dams.
- Over population, Industrialisation, urbanisation and increased global needs.

Effects of deforestation

- Burning of forest wood release stored carbon, a negative impact just opposite of carbon sequestration.
- Trees and plants bind the soil particles. The removal of forest cover increases soil erosion and decreases soil fertility. Deforestation in dry areas leads to the formation of deserts.
- The amount of runoff water increases soil erosion and also creates flash flooding, thus reducing moisture and humidity.
- The alteration of local precipitation patterns leading to drought conditions in many regions. It triggers adverse climatic conditions and alters water cycle in ecosystem.
- It decreases the bio-diversity significantly as their habitats are disturbed and disruption of natural cycles.
- Loss of livelihood for forest dwellers and rural people.
- Increased global warming and account for one-third of total CO_2 emission.
- Loss of life support resources, fuel, medicinal herbs and wild edible fruits.

8.4 Afforestation

Afforestation is planting of trees where there was no previous tree coverage and the conversion of non-forested lands into forests by planting suitable trees to retrieve the vegetation. Example: Slopes of dams afforested to reduce water run-off, erosion and siltation. It can also provide a range of environmental services including carbon sequestration, water retention.

The Man who Single Handedly Created a Dense Forest

Jadav "Molai" Payeng (born 1963) is an environmental activist has single-handedly planted a forest in the middle of a barren wasteland. This Forest Man of India has transformed the world's largest river island, Majuli, located on one of India's major rivers, the Brahmaputra, into a dense forest, home to rhinos, deers, elephants, tigers and birds. And today his forest is larger than Central Park.

Former vice-chancellor of Jawahar Lal Nehru University, Sudhir Kumar Sopory named Jadav Payeng as **Forest Man of India**, in the month of October 2013. He was honoured at the Indian Institute of Forest Management during their annual event 'Coalescence'. In 2015, he was honoured with Padma Shri, the fourth highest civilian award in India. He received honorary doctorate degree from Assam Agricultural University and Kaziranga University for his contributions.

Afforestation Objectives

- To increase forest cover, planting more trees, increases O_2 production and air quality.
- Rehabilitation of degraded forests to increase carbon fixation and reducing CO_2 from atmosphere.
- Raising bamboo plantations.
- Mixed plantations of minor forest produce and medicinal plants.
- Regeneration of indigenous herbs / shrubs.
- Awareness creation, monitoring and evaluation.
- To increase the level and availability of water table or ground water and also to reduce nitrogen leaching in soil and nitrogen contamination of drinking water, thus making it pure not polluted with nitrogen.
- Nature aided artificial regeneration.

Achievements

- Degraded forests were restored
- Community assets like overhead tanks bore-wells, hand pumps, community halls, libraries, etc were established
- Environmental and ecological stability was maintained.
- Conserved bio-diversity, wildlife and genetic resources.
- Involvement of community especially women in forest management.

8.5 Alien invasive species

Invasion of alien or introduced species disrupts ecosystem processes, threaten biodiversity, reduce native herbs, thus reducing the ecosystem services (benefits). During eradication of these species, the chemicals used increases greenhouse gases. Slowly they alter ecosystem, micro climate and nature of soil and make it unsuitable for native species and create human health problems like allergy, thus resulting in local environmental degradation and loss of important local species.

According to World Conservation Union invasive alien species are the second most significant threat to bio-diversity after habitat loss.

What is invasive species?

A non-native species to the ecosystem or country under consideration that spreads naturally, interferes with the biology and existence of native species, poses a serious threat to the ecosystem and causes economic loss.

It is established that a number of invasive species are accidental introduction through ports via air or sea. Some research organisations import germplasm of wild varieties through which also it gets introduced. Alien species with edible fruits are usually spread by birds.

Invasive species are fast growing and are more adapted. They alter the soil system by changing litter quality thereby affecting the

soil community, soil fauna and the ecosystem processes.

It has a negative impact on decomposition in the soils by causing stress to the neighbouring native species. Some of the alien species which cause environmental issues are discussed below

Eichhornia crassipes

Figure 8.4:
Eichhornia crassipes

It is an invasive weed native to South America. It was introduced as aquatic ornamental plant, which grows faster throughout the year. Its widespread growth is a major cause of biodiversity loss worldwide. It affects the growth of phytoplanktons and finally changing the aquatic ecosystem.

It also decreases the oxygen content of the waterbodies which leads to eutrophication. It poses a threat to human health because it creates a breeding habitat for disease causing mosquitoes (particularly *Anopheles*) and snails with its free floating dense roots and semi submerged leaves. It also blocks sunlight entering deep and the waterways hampering agriculture, fisheries, recreation and hydropower.

Prosopis juliflora

Prosopis juliflora is an invasive species native to Mexico and South America. It was first introduced in Gujarat to counter desertification and later on in Andhra Pradesh, Tamil Nadu as a source of firewood. It is an aggressive coloniser and as a consequence the habitats are rapidly covered by this species. Its invasion reduced the cover of native medicinal herbaceous species. It is used to arrest wind erosion and stabilize sand dunes on coastal and desert areas. It can absorb hazardous chemicals from soil and it is the main source of charcoal.

Figure 8.5:
Prosopis juliflora

8.6 Conservation

India due to its topography, geology and climate patterns has diverse life forms. Now this huge diversity is under threat due to many environmental issues for this conservation becomes an important tool by which we can

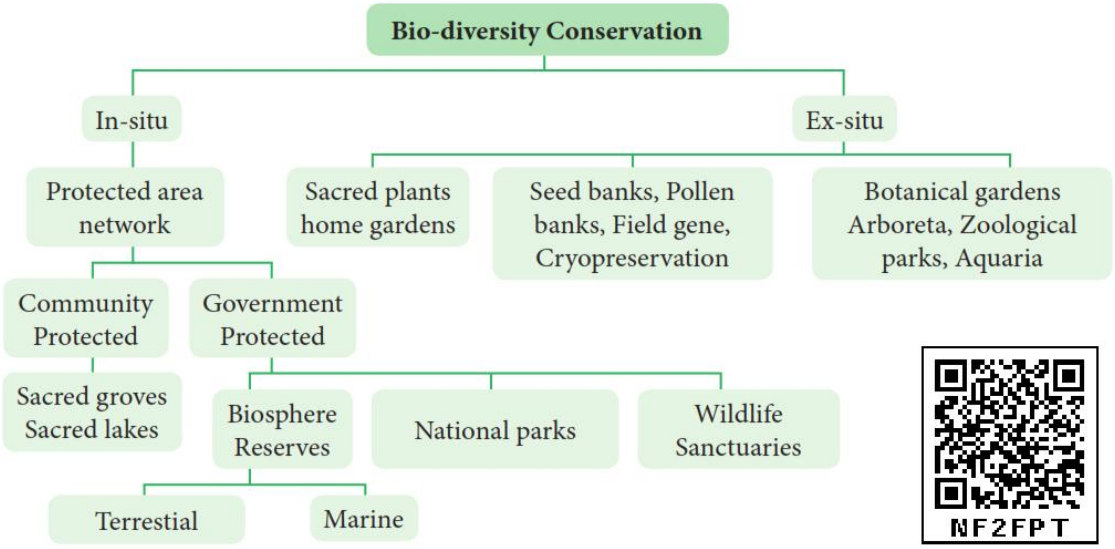

Figure 8.6: Flow chart on biodiversity conservation

Conservation movement

A community level participation can help in preservation and conservation of our environment. Our environment is a common treasure for all the living organisms on earth. Every individual should be aware of this and participate actively in the programs meant for the conservation of the local environment. Indian history has witnessed many people movements for the protection of environment.

Chipko Movement

The tribal women of Himalayas protested against the exploitation of forests in 1972. Later on it transformed into **Chipko Movement** by **Sundarlal Bahuguna** in Mandal village of Chamoli district in 1974. People protested by hugging trees together which were felled by a sports goods company. Main features of Chipko movement were,

- This movement remained non political
- It was a voluntary movement based on Gandhian thought.
- It was concerned with the ecological balance of nature
- Main aim of Chipko movement was to give a slogan of five F's – Food, Fodder, Fuel, Fibre and Fertilizer, to make the communities self sufficient in all their basic needs.

Appiko Movement

The famous Chipko Andolen of Uttarakhand in the Himalayas inspired the villagers of Uttar Karnataka to launch a similar movement to save their forests. This movement started in Gubbi Gadde a small village near Sirsi in Karnataka by Panduranga Hegde. This movement started to protest against felling of trees, monoculture, forest policy and deforestation.

reduce many species getting lost from our native land. By employing conservation management strategies like germplasm conservation, in situ, ex-situ, in-vitro methods, the endemic as well as threatened species can be protected

In-situ conservation

It means conservation and management of genetic resources in their natural habitats. Here the plant or animal species are protected within the existing habitat. Forest trees, medicinal and aromatic plants under threat are conserved by this method. This is carried out by the community or by the State conservation which include wildlife, National park and Biosphere reserve. The ecologically unique and biodiversity rich regions are legally protected as wildlife sanctuaries, National parks and Biosphere reserves. Megamalai, Sathyamangalam wildlife, Guindy and Periyar National park, and Western ghats, Nilgiris, Agasthyamalai and Gulf of Mannar are the biosphere reserves of Tamil Nadu.

Sacred groves

These are the patches or grove of cultivated trees which are community protected and are based on strong religious belief systems which usually have a significant religious connotation for protecting community. Each grove is an abode of a deity mostly village God Or Goddesses like Aiyanar or Amman. 448 grooves were documented throughout Tamil Nadu, of which 6 groves (Banagudi shola, Thirukurungudi and Udaiyankudikadu, Sittannnavasal, Puthupet and Devadanam) were taken up for detailed floristic and faunistic studies. These groves provide a number of ecosystem services to the neighbourhood like protecting watershed, fodder, medicinal plants and micro climate control.

Ex-situ conservation

It is a method of conservation where species are protected outside their natural environment. This includes establishment of botanical gardens, zoological parks, conservation strategies such as gene, pollen, seed, in-vitro conservation, cryo preservation, seedling, tissue culture and DNA banks. These facilities not only provide housing and care for endangered species, but

also have educational and recreational values for the society

8.6.1 Endemic Centres and Endemic Plants

Endemic species are plants and animals that exist only in one geographic region. Species can be endemic to large or small areas of the earth. Some are endemic to a particular continent, some to a part of a continent and others to a single island.

Any species found restricted to a specified geographical area is referred to as ENDEMIC.. It may be due to various reasons such as isolation, interspecific interactions, seeds dispersal problems, site specificity and many other environmental and ecological problems. There are 3 Megacentres of endemism and 27 microendemic centres in India. Approximately one third of Indian flora have been identified as endemic and found restricted and distributed in three major phytogeographical regions of india, that is Indian Himalayas, Peninsular India and Andaman nicobar islands. Peninsular India, especially Western Ghats has high concentration of endemic plants. *Hardwickia binata* and *Bentinckia condapanna* are good examples for endemic plants. A large percentage of Endemic species are herbs and belong to families such as Poaceae. Apiaceae, Asteraceae and Orchidaceae.

Endemic plants	Habit	Name of endemic centre
Baccaurea courtallensis	Tree	Southern Western Ghats
Agasthiyamalaia pauciflora	Tree	Peninsular india
Hardwickia binata	Tree	Peninsular and northern India
Bentinckia condappana	Tree	Western ghats of Tamil Nadu and kerala
Nepenthes khasiyana	Liana	Khasi hills, Meghalaya

Table 1: Endemic plants

Majority of endemic species are threatened due to their narrow specific habitat, reduced seed production, low dispersal rate, less viable nature and human intereferences.. Serious efforts need to be undertaken for their conservation, otherwise these species may become globally extinct.

Figure 8.7: Endemic Plants

a. *Bentinckia condapanna* **b.** *Baccaurea courtallensis*

8.7 Carbon Capture and Storage (CCS)

Carbon capture and storage is a technology of capturing carbondioxide and injects it deep into the underground rocks into a depth of 1 km or more and it is an approach to mitigate global warming by capturing CO_2 from large point sources such as industries and power plants and subsequently storing it instead of releasing it into the atmosphere. Various safe sites have been selected for permanent storage in various deep geological formations, liquid storage in the Ocean and solid storage by reduction of CO_2 with metal oxide to produce stable carbonates. It is also known as Geological sequestration which involves injecting CO_2 directly into the underground geological formations (such as declining oil fields, gas fields saline aquifers and unmineable coal have been suggested as storage sites).

Carbon Sequestration

Carbon sequestration is the process of capturing and storing CO2 which reduces the amount of CO2 in the atmosphere with a goal of reducing global climate change.

Carbon sequestration occurs naturally by plants and in ocean. Terrestrial sequestration is typically accomplished through forest and soil conservation practices that enhance the storage carbon.

As an example microalgae such as species of *Chlorella*, *Scenedesmus*, *Chroococcus* and *Chlamydomonas* are used globally for CO_2 sequestration. Trees like *Eugenia caryophyllata*,

Tecomastans, *Cinnamomum verum* have high capacity and noted to sequester carbon macroalgae and marine grasses and mangroves are also have ability to mitigate carbon-di-oxide.

Carbon Foot Print (CFP)

Every human activity leaves a mark just like our footprint. This **Carbon foot print** is the total amount of green house gases produced by human activities such as agriculture, industries, deforestation, waste disposal, buring fossil fuels directly or indirectly. It can be measured for an individual, family, organisation like industries, state level or national level. It is usually estimated and expressed in equivalent tons of CO_2 per year. The burning of fossil fuels releases $CO_2$and other green house gases. In turn these emissions trap solar energy and thus increase the global temperature resulting in ice melting, submerging of low lying areas and inbalance in nature like cyclones, tsunamis and extreme weather conditions. To reduce the carbon foot print we can follow some practices like (i) Eating indigenous fruits and products (ii) Reduce use of your electronic devices (iii) Reduce travelling (iv) Do not buy fast and preserved, processed, packed foods. (v) Plant a garden (vi) Less consumption of meat and sea food. Poultry requires little space, nutrients and less pollution comparing cattle farming. (vii) reduce use of Laptops (when used for 8 hours, it releases nearly 2 kg. of CO_2 annually) (viii) Line dry your clothes. (Example: If you buy imported fruit like kiwi, indirectly it increases CFP. How? The fruit has travelled a long distance in shipping or airliner thus emitting tons of CO_2)

Carbon Sink

Any system having the capacity to accumulate more atmospheric carbon during a given time interval than releasing CO_2. Example: forest, soil, ocean are natural sinks. Landfills are artificial sinks.

Biochar

Biochar is another long term method to store carbon. To increase plants ability to store more carbon, plants are partly burnt such as crop waste, waste woods to become carbon rich slow decomposing substances of material called Biochar. It is a kind of charcoal used as a soil amendment. Biochar is a stable solid, rich in carbon and can endure in soil for thousands of years. Like most charcoal, biochar is made from biomass via pyrolysis. (Heating biomas in low oxygen environment) which arrests wood from complete burning. Biochar thus has the potential to help mitigate climate change via carbon

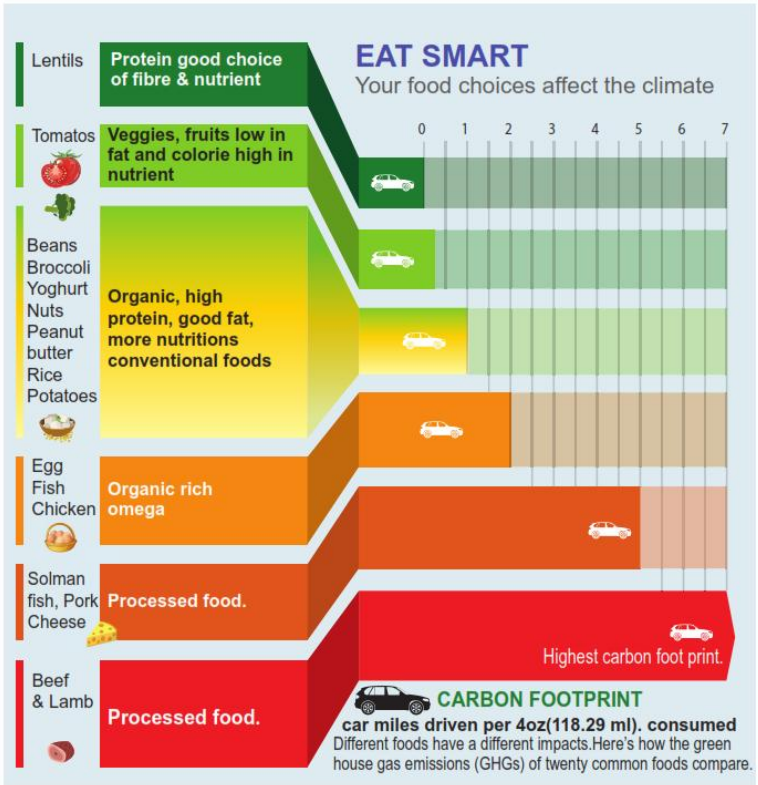

Figure 8.8: Carbon foot print

sequestration. Independently, biochar when added to soil can increase soil fertility of acidic soils, increase agricultural productivity, and provide protection against some foliar and soil borne diseases. It is a good method of preventing waste woods and logs getting decayed instead we can convert them into biochar thus converting them to carbon storage material.

8.8 Rain water harvesting – RWH (Solution to water crisis – A ecological problem)

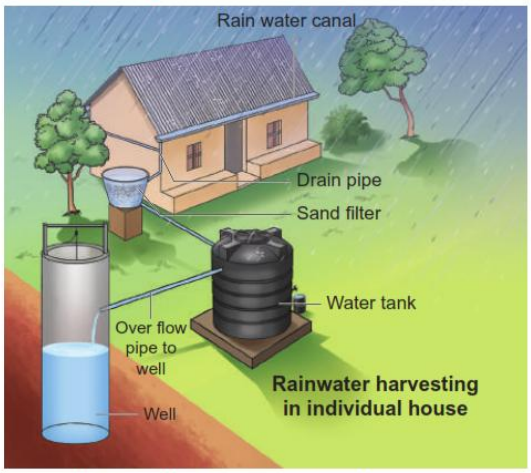

Figure 8.9: Pictures of Rain Water Harvesting Structures in Ooraniers

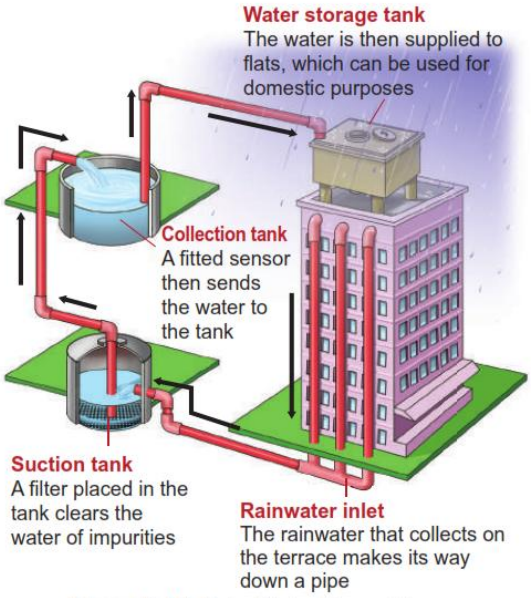

Figure 8.10: Rain Water Harvesting Structures in Water Supply sources

Rainwater harvesting is the accumulation and storage of rain water for reuse in-site rather than allowing it to run off. Rainwater can be collected from rivers, roof tops and the water collected is directed to a deep pit. The water percolates and gets stored in the pit. RWH is a sustainable water management practice implemented not only in urban area but also in agricultural fields, which is an important economical cost effective method for the future.

8.8.1 Environmental benefits of Rain Water Harvesting:

- Promotes adequacy of underground water and water conservation.
- Mitigates the effect of drought.
- Reduces soil erosion as surface run-off is reduced.
- Reduces flood hazards.
- Improves groundwater quality and water table / decreases salinity.
- No land is wasted for storage purpose and no population displacement is involved.
- Storing water underground is an eco-friendly measure and a part of sustainable water storage strategy for local communities.

8.8.2 Importance of Lakes

Water bodies like lakes, ponds not only provide us a number of environmental benefits but they strengthen our economy as well as our quality of life like health. Lakes as a storage of rain water provides drinking water, improves ground water level and preserve the fresh water bio-diversity and habitat of the area where in occurs.

In terms of services lakes offer sustainable solutions to key issues of water management and climatic influences and benefits like nutrient retention, influencing local rainfall, removal of pollutants, phosphorous and nitrogen and carbon sequestration.

8.9 Environmental Impact Assessment (EIA)

Environmental Impact Assessment is an environmental management tool. It helps to regulate and recommend optimal use of natural resources with minimum impact on ecosystem and biotic communities. It is used to predict the environmental consequences of future proposed developmental projects (example: river projects, dams, highway projects) taking into account inter-related socio-economic, cultural and human-health impacts. It reduces environmental stress thus helping to shape the projects that may suit local environment by ensuring optimal utilization of natural resources and disposal of wastes to avoid environmental degradation.

The benefits of EIA to society

- A healthier environment
- Maintenance of biodiversity
- Decreased resource usage
- Reduction in gas emission and environment damage

Biomonitoring

The act of observing and assessing the current state and ongoing changes in ecosystem, biodiversity components, landscape including natural habitats, populations and species.

An agricultural drone is an unmanned aerial vehicle applied to farming in order to help increased crop production and monitor crop growth. Agricultural drones let farmers see their fields from the sky. This bird's eye-view can reveal many issues such as irrigation problems, soil variation and pest and fungal infestations. It is also used for cost effective safe method of spraying pesticides and fertilizers, which proves very easy and non-harmful.

Figure 8.11: Agricultural drone

8.9.1 Biodiversity Impact Assessment (BIA)

Biodiversity Impact Assessment can be defined as a decision supporting tool to help biodiversity inclusive of development, planning and implementation. It aims at ensuring development proposals which integrate bio-diversity considerations. They are legally compliant and include mechanisms for the conservation of bio-diversity resources and provide fair and equitable sharing of the benefits arising from the use of bio-diversity.

Bio-diversity impacts can be assessed by

- Change in land use and cover
- Fragmentation and isolation
- Extraction
- External inputs such as emissions, effluents and chemicals
- Introduction of invasive, alien or genetically modified species
- Impact on endemic and threatened flora and fauna.

8.10 Geographic Information System

GIS is a computer system for capturing, storing, checking and displaying data related to positions on Earth's surface. Also to manipulate, analyse, manage and present spacial or geographic data.

GPS is a satellite navigation system used to determine the ground position of an object. It is a **constellation** of approximately 30 well spaced satellites that orbit the earth and make it possible for the people with ground receivers to pinpoint their geographic location. Some applications in which GPS is currently being used for around the world include Mining, Aviation, Surveying Agricultural and Marine ecosystem.

Importance of GIS

- Environmental impact assessment
- Disaster management
- Zoning of landslide hazard

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- Determination of land cover and land use
- Estimation of flood damage
- Management of natural resources
- Soil mapping
- Wetland mapping
- Irrigation management and identification of volcanic hazard
- Vegetation studies and mapping of threatened and endemic species.

Remote Sensing is the process of detecting and monitoring the physical characteristics of an area by measuring its reflected and emitted radiation at a distance from the targeted area. It is an tool used in conservation practices by giving exact picture and data on identification of even a single tree to large area of vegetation and wild life for classification of land use patterns and studies, identification of biodiversity rich or less areas for futuristic works on conservation and maintenance of various species including commercial crop, medicinal plants and threatened plants.

Specific uses

- Helps predicting favourable climate, for the study of spreading of disease and controlling it.
- Mapping of forest fire and species distribution.
- Tracking the patterns of urban area development and the changes in Farmland or forests over several years
- Mapping ocean bottom and its resources

Applications of Satellites

Name of the Satellites	Year of Launch	Application
SCATSAT – I	Sep. 2016	Weather forecasting, cyclone prediction and tracking services in India
INSAT 3DR	Sep. 2016	Disaster management
CARTOSAT – 2	Jan. 2018	Earth observation
GSAT – 6A	March 2018	Communication
CARTOSAT – 2 (100^{th} Satellite)	Jan. 2018	To watch border surveillance

Summary

Green house effect leads to climate change which results in global warming. Deforestation causes soil erosion, whereas Afforestation helps to restore vegetation and increases ground water table. Regeneration of trees by Agroforestry is possible with the involvement of community and government. Help to conserve the flora and fauna in their natural habitat and man-made environments like zoological parks and national parks. Mitigation of carbon in the atmosphere done in the form of sequestration. Rain water harvesting is done for improving the ground water table. Importance and location of lakes in Tamil Nadu which aids water supply to the city is a measure of conservation of drinking water. Assessment of Environment and Biodiversity helps to study risk analysis and disaster management. Forest cover is monitored through Remote sensing and GIS.

Evaluation

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1. Which of the following would most likely help to slow down the greenhouse effect.
   a) Converting tropical forests into grazing land for cattle.
   b) Ensuring that all excess paper packaging is buried to ashes.
   c) Redesigning landfill dumps to allow methane to be collected.
   d) Promoting the use of private rather than public transport.
2. With respect to *Eichhornia*
   Statement A: It drains off oxygen from water and is seen growing in standing water.
   Statement B: It is an indigenous species of our country.
   a) Statement A is correct and Statement B is wrong.
   b) Both Statements A and B are correct.
   c) Statement A is correct and Statement B is wrong.
   d) Both statements A and B are wrong.

3. Find the wrongly matched pair.
   a) Endemism - Species confined to a region and not found anywhere else.
   b) Hotspots - Western ghats
   c) Ex-situ Conservation - Zoological parks
   d) Sacred groves - Saintri hills of Rajasthan
   e) Alien sp. Of India - Water hyacinth

4. Depletion of which gas in the atmosphere can lead to an increased incidence of skin cancer?
   a) Ammonia b) Methane
   c) Nitrous oxide d) Ozone

5. One green house gas contributes 14% of total global warming and another contributes 6%. These are respectively identified as
   a) N_20 and CO_2 b) CFCs and N_20
   c) CH_4 and CO_2 d) CH_4 and CFCS

6. One of the chief reasons among the following for the depletion in the number of species making endangered is
   a) over hunting and poaching
   b) green house effect
   c) competition and predation
   d) habitat destruction

7. Deforestation means
   a) growing plants and trees in an area where there is no forest
   b) growing plants and trees in an area where the forest is removed
   c) growing plants and trees in a pond
   d) removal of plants and trees

8. Deforestation does not lead to
   a) Quick nutrient cycling
   b) soil erosion
   c) alternation of local weather conditions
   d) Destruction of natural habitat weather conditions

9. The unit for measuring ozone thickness
   a) Joule b) Kilos
   c) Dobson d) Watt

10. People's movement for the protection of environment in Sirsi of Karnataka is
    a) Chipko movement
    b) Amirtha Devi Bishwas movement
    c) Appiko movement
    d) None of the above

11. The plants which are grown in silivpasture system are
    a) Sesbania and Acacia
    b) Solenum and Crotalaria
    c) Clitoria and Begonia
    d) Teak and sandal

12. What is ozone hole?

13. Give four examples of plants cultivated in commercial agroforestry.

14. Expand CCS.

15. How do forests help in maintaining the climate?

16. How do sacred groves help in the conservation of biodiversity?

17. Which one gas is most abundant out of the four commonest greenhouse gases? Discuss the effect of this gas on the growth of plants?

18. Suggest a solution to water crisis and explain its advantages.

19. Explain afforestation with case studies.

20. What are the effects of deforestation and benefits of agroforesty?

Glossary

Algae Blooms: Sudden sprout of algae growth, which can affect the water quality adversely and indicate potentially hazardous changes in local water chemistry.

Atmosphere: A major regional community of plants and animals with similar life forms and environmental conditions.

Biodegradable waste: Organic waste, typically coming from a plant or animal sources, which other living organisms can break done.

Biosphere: The portion of earth and its atmosphere that can support life.

Oil spill: The harmful release of oil into the environment, usually through water, which is very difficult to clean up and often kills, birds, fish and other wildlife.

Radiation: A form of energy that is transmitted in waves, rays or particles from a natural source such as the sun and the ground or an artificial source such as an X-ray machine.

Radioactive: A materials is said to be radioactive if it emits radiation.

Recycle:To break waste items done into their raw materials, which are then used to remake the original item or to make new items.

Sustainable development: Development using hand of energy sources in a way that meets the needs of people today without reducing the ability in future generation to meet their own needs.

ICT Corner

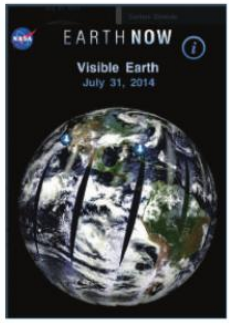
Environmental Issues

Let us know about the Environmental issues using the **EARTH NOW** app through this activity.

Steps

- Type the URL or scan the QR code to open the activity page.
- Click on the satellite it displays the shape and activities of the satellite.
- Click on the Vital Signs to see the global Climate data including surface air temperature, Carbondioxide, Ozone, etc.,

Step 1



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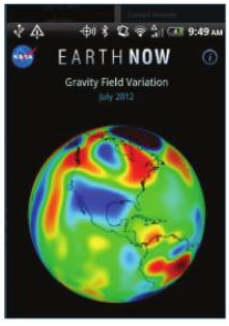
Step 3



Step 4

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* Pictures are indicative only

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Chapter

9

Unit X: Economic Botany

Plant Breeding

Learning Objectives

The learner will be able to

- Appreciate the relationship between humans and plants.
- Recognise the origin of agriculture.
- Perceive the importance of organic agriculture.
- Understand the different conventional methods of plant breeding.

Chapter outline

Q4VYTG

Economic botany is the study of the relationship between people and economically important plants. It explores the ways by which humans use plants for food, medicines and other uses. Economic botany intersects many fields including established disciplines such as agronomy, anthropology, archaeology, chemistry, trade and commerce.

9.1 Relationship between humans and plants

From the very early times, human beings have co-existed with plants which played a vital role in their survival. Through a long process of trial and error, our ancestors have selected hundreds of wild plants from the various parts of the world for their specific use. The knowledge of the plants and its applications have led to the development of the humans and their civilization in many ways.

9.2 Domestication of plants

Domestication is the process of bringing a plant species under the control of humans and gradually changing it through careful selection, genetic alteration and handling so that it is more useful to people. The domesticated species are renewable sources that have provided food and other benefits to human.

The possible changes in the plant species due to domestication are listed below;

- Adaptation to a greater diversity of environments and a wider geographical range.
- Simultaneous /uniform flowering and fruiting.

- Lack of shattering or scattering of seeds.
- Increased size of fruits and seeds.
- Change from a perennial to annual habit.
- Change in breeding system.
- Increased yield.
- Increased resistance for disease and pest.
- Developing seedless parthenocarpic fruit.
- Enhancing colour, appearance, palatability and nutritional composition.

9.3 Origin of Agriculture

Archeological evidence for earliest record of agriculture is found in the fertile crescent region in and around Tigris and Euphrates river valleys, approximately about 12,000 years ago.

The earlier Greek and Roman naturalists like Theophrastus, Dioscorides, Pliny the elder and Galen laid down the scientific foundation in understanding origin and domestication of cultivated plants.

9.4 History of Agriculture

1807 Alexander Von Humboldt considered the original sources of most useful plants and their origin is an impenetrable secret.

1868 Darwin's evolutionary theory proposed that origin of useful cultivated plants have existed through natural selection and hybridisation.

1883 De Candolle in his "Origin of cultivated plants" studied 247 cultivated plant species and attempted to solve the mystery about the ancestral form, region of domestication and history.

1887- 1943 Nikolai Ivanovich Vavilov made an inventory of the diverse forms of our most important cultivated plants and their distribution based on variety of facts obtained from morphology, anatomy, cytology, genetics and plant geography. Vavilov has given the centre of diversity of a crop species which may be the centre of origin for that species.

Vavilov initially proposed eight main geographic centres of origin originally in 1926. Later (1935) he named 11 centres of origin by dividing few centres into two and three centres and added a new centre USA thus making the 8 centres of origin into 12.

1968 Zhukovsky put forward the concept of mega gene centre for the origin of cultivated plants. He divided the whole world into 12 mega gene centres.

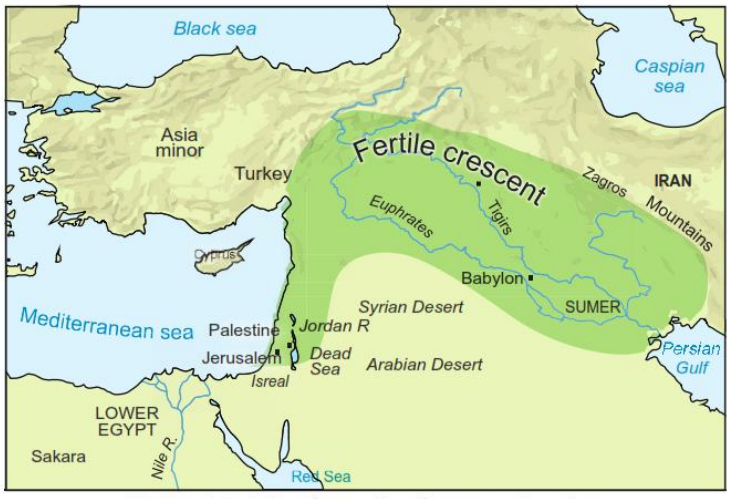

Figure 9.1: Map shows Fertile crescent region

1971 According to Harlan, agriculture originated independently in three different areas in different times or simultaneously. Hence a crop may not have a single centre of origin. Harlan says that the centre of crop plant means the places of agricultural origin of the crop plants. The non-centre denotes the place where agriculture of the crop was introduced and spread. Thus centre and non-centre interact with each other.

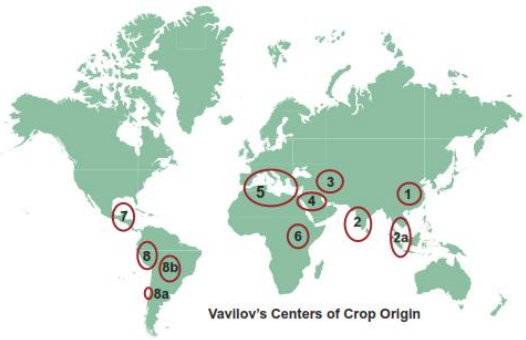

Figure 9.2: Vavilov's centres of crop origin and crops domesticated

Vavilov's Centre of Crop Origin		Crops domesticated
1	China	Foxtail millet, soybean, bamboo, onion, crucifers.
2	India	Rice, sugarcane, mango, orange, eggplant, sesame.
2 a	South East Asia	Rice, banana, coconut, clove , hemp.
3	Central East	Wheat, pea, hemp, cotton etc.
4	The Near East	Wheat, rye, many subtropical and tropical fruits.
5	Mediterranean	Olive, vegetables, oil yielding plants, wheats
6	Ethiopia (Abyssinian)	Wheat, barley, sesame, castor, coffee.
7	Mesoamerica (South Mexican & Central American Centre)	Maize, bean, sweet potato, papaya, guava, tobacco.
8	South America	Tomato, pine-apple
8 a	The Chiloe Centre	Potato
8 b	The Brazilian –Paraguayan Centre	Groundnut, cashew nut, pine apple, peppers, rubber.

9.5 Organic Agriculture

Organic farming is an alternative agricultural system which originated early in the twentieth century in reaction to rapidly changing farming practices. It is a production system that sustains the health of the soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions rather than the use of inputs with adverse effects.

Indian Plant Breeders

a. **Dr. M. S. Swaminathan** – He is pioneer mutation breeder.

b. **Sir. T.S. Venkataraman** – An eminent sugarcane breeder.

c. **Dr. B.P. Pal** – Famous wheat breeder, developed superior disease resistant varieties of wheat.

d. **Dr. K. Ramiah** – Eminent rice breeder, developed several high yielding varieties of rice.

e. **N.G.P. Rao** – An eminent sorghum breeder, developed world's first hybrid of Sorghum (CSH-1).

f. **C.T. Patel** – Who developed world's first cotton hybrid.

g. **Choudhary Ram Dhan** – Wheat breeder, who is famous for C-591 variety of wheat, which is made Punjab as wheat granary of India.

9.5.1. Biofertilizers

Biofertilizers are defined as preparations containing living cells or latent cells of efficient strains of microorganisms that help crop plants uptake of nutrients by their interactions in the rhizosphere when applied through seed or soil. Biofertilizers could be also called as microbial cultures, bioinoculants, bacterial inoculants or bacterial fertilizers.

They are efficient in fixing nitrogen, solubilising phosphate and decomposing cellulose. They are designed to improve the soil fertility, plant growth, and also the number and biological activity of beneficial microorganisms in the soil. They are eco-friendly organic agro inputs and are more efficient and cost effective than chemical fertilizers.

S.N	Groups		Examples
A	**N_2 fixing Biofertilize**		
	1.	Free-living	*Azotobacter, Clostridium, Anabaena, Nostoc,*
		Symbiotic	*Rhizobium, Anabaena azollae*
	3.	Associative Symbiotic	*Azospirillum*
B	**P Solubilizing Biofertilizer**		
	1.	Bacteria	*Bacillus subtilis, Pseudomonas striata*
	2.	Fungi	*Penicillium, Aspergillus.*
C	**P Mobilizing Biofertilizers**		
	1.	Arbuscular Mycorrhiza	*Glomus, Scutellospora.*
	2.	Ectomycorrhiza	*Amanita.*
D	**Biofertilizer for Micro nutrients**		
	1.	Silicate and Zinc solubilizers	*Bacillus.*
E	**Plant Growth Promoting Rhizobacteria**		
	2.	Pseudomonas	*Pseudomonas fluorescence*

Figure 9.3: Classification of Biofertilizers

Rhizobium

Bio-fertilisers containing rhizobium bacteria are called rhizobium bio-fertilizer culture. Symbiotic bacteria that reside inside the root nodules convert the atmospheric nitrogen into a bio available form to the plants. This nitrogen fixing bacterium when applied to the soil undergoes multiplication in billions and fixes the atmospheric nitrogen in the soil. Rhizobium is best suited for the paddy fields which increase the yield by 15 – 40%.

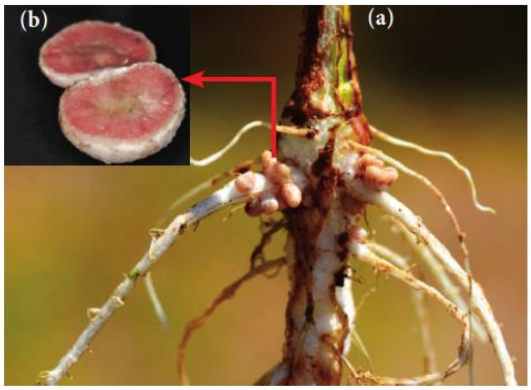

Figure 9.4 (a) : Root nodules occur on root
(b) C.S. of Root nodule

Azolla

Azolla is a free-floating water fern that fixes the atmospheric nitrogen in association with nitrogen fixing blue green alga *Anabaena azolla*. It is used as a bio-fertilizer for wetland rice cultivation and is known to contribute 40 – 60 kg/ha/crop. The agronomic potential of Azolla is quite significant particularly for increasing the yield of rice crop, as it quickly decompose in soil.

Figure 9.5: (a) *Azolla* in paddy field
(b) *Azolla*

Arbuscular mycorrhizae

Arbuscular mycorrhizae (AM) is formed by the symbiotic association between certain phycomycetous fungi and angiosperm roots. They have the ability to dissolve the phosphates found in abundance in the soil.

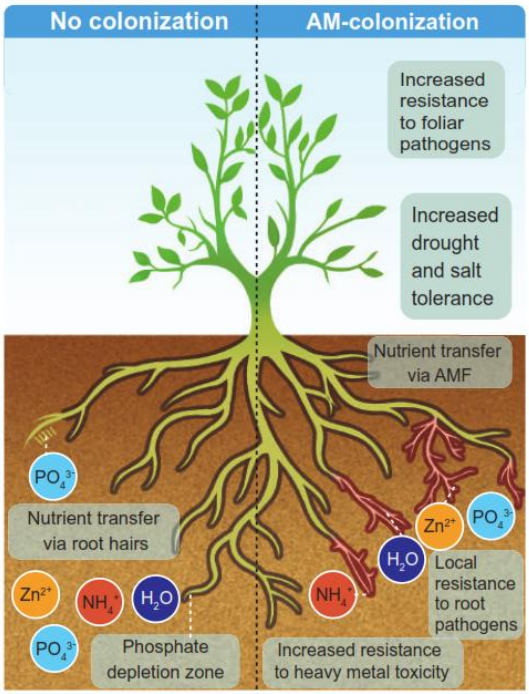

Figure 9.6 Benefits of AM colonisation

Apart from increasing the availability of phosphorus, AM provides necessary strength to resist disease, germs and unfavourable weather conditions. It also assures water availability.

Seaweed Liquid Fertilizer

Seaweedliquidfertilizer(SLF)containscytokinin, gibberellins and auxin apart from macro and micro nutrients. Most seaweed based fertilizers are made from kelp(brown algae) which grows to length of 150 metres. Liquid seaweed fertilizer is not only organic but also eco-friendly. The alginates in the seaweed that reacts with metals in the soil and form long, cross-linked polymers in the soil. These polymers improve the crumbing in the soil, swell up when they get wet and retain moisture for a long time. They are especially useful in organic gardening which provides carbohydrates for plants. Seaweed has more than 70 minerals, vitamins and enzymes. It promotes vigorous growth. Improves resistance of plants to frost and disease. Seeds soaked in seaweed extract germinate much rapidly and develop a better root system.

Figure 9.7 : Seaweed – Kelp

Bio-Pesticides

Bio-pesticides are biologically based agents used for the control of plant pests. They are in high use due to their non-toxic, cheaper and eco-friendly characteristics as compared to chemical or synthetic pesticides. Bio-pesticides have become an integral component of pest management in terms of the environmental and health issues attributed to the use of chemicals in agriculture.

Trichoderma species are free-living fungi that are common in soil and root ecosystem. They have been recognized as bio-control agent for (1) the control of plant disease (2) ability to enhance root growth development (3) crop productivity (4) resistance to abiotic stress and (5) uptake and use of nutrients.

Figure 9.8:
(a) *Trichoderma* fungi

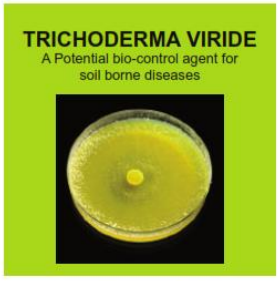

Figure 9.8:
(b) Biopesticide

Beauveria species is an entomo-pathogenic fungus that grows naturally in soils throughout the world. It acts as a parasite on various arthropod species causing white muscardine disease without affecting the plant health and growth. It also controls damping off of tomato caused by *Rhizoctonia solani.*

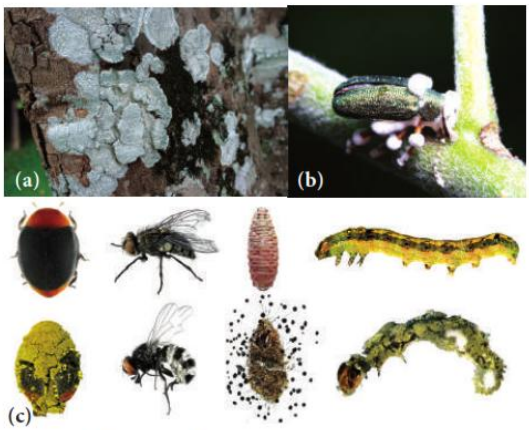

Figure 9.9 : (a) *Beauveria* Fungi
(b) *Beauveria* sps infected insect on green plant
(c)Entomopathogenic fungi on insets

Green Manuring

Green manuring is defined as the growing of green manure crops and use of these crops directly in the field by ploughing. One of the main objectives of the green manuring is to increase the content of nitrogen in the soil. Also it helps in improving the structure and physical properties of the soil. The most important green manure crops are *Crotalaria juncea, Tephrosia purpurea, Indigofera tinctoria*