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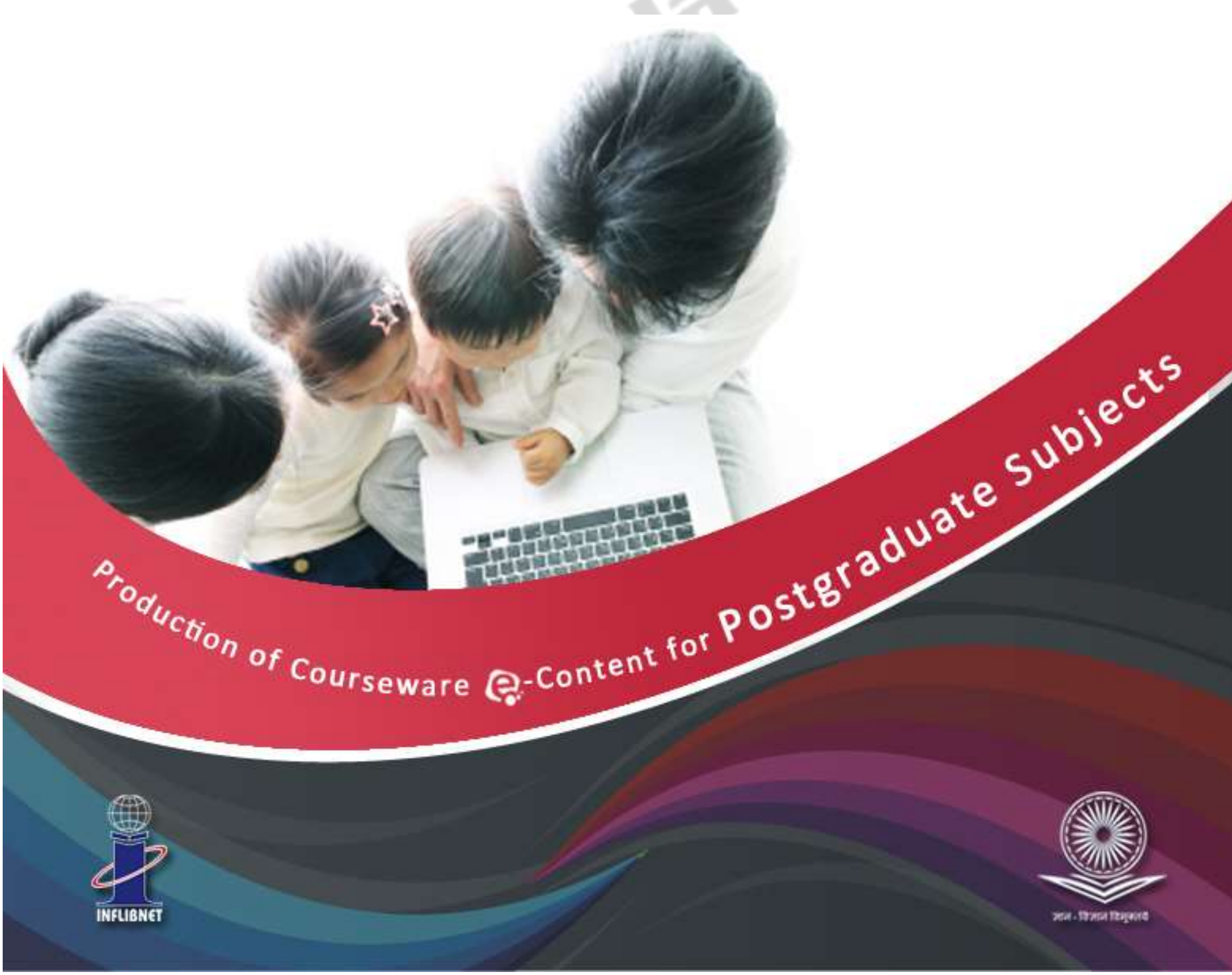

1. Details of Module and its Structure

Module Detail	
Subject Name	<Botany>
Paper Name	<Ecology>
Module Name/Title	<Climax concept and examples of succession>
Module Id	
Pre-requisites	<Basic knowledge about Succession >
Objectives	<To make students aware about Climax Concept and examples of Succession >
Keywords	Climax concept of Succession, Monoclimax theory, Polyclimax theory, Climax pattern theory, Hydrosere, Xerosere

Structure of Module / Syllabus of a module (Define Topic / Sub-topic of module)	
<Succession>	Climax concept, Theories explaining climax, Examples of hydrosere and xerosere

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Climax Concept and Examples of Succession

Climax Concept

Characteristics of Climax

Term ‘Climax’ was derived from a Greek word ‘klîmax’ meaning ladder or the first step of the ladder. Climax community in ecology is the mature, relatively self-maintaining seral stage in which the succession terminates. In a climax community all the species component of that community perpetuate themselves through reproduction till the climate remain the same. In a climax community the species composition should remain the same over a long period of time with all the growth forms ranging from seedling to maturity stage. Climax community, however, is not a static community rather maintaining dynamic equilibrium with the physical and biotic environment. This dynamic balance or equilibrium is maintained through various forms of interaction among the species, and between the species and environment through energy flow, nutrient cycling, food web, etc. Climax community generally has certain characteristics. The climax vegetation is tolerant of the prevailing environmental conditions and tends to be mesic. It has generally high species diversity and complex and higher degree of ecological organization.

Theories explaining Climax

There are major three theoretical approaches to identify and describe the climax communities and they are:

(1) Monoclimax Theory (Clements 1916, 1936)

(2) Polyclimax Theory (Tansley 1935)

(3) Climax pattern Theory (Whittaker 1955)

(I) Monoclimax Theory or Climatic climax theory:

This theory was proposed by Clements in 1916. As per this theory 'Climate is the cause and climax in the result'. Since for each major climate there will be only one climax, and this climax is known as 'Climatic climax'. In other words it is the climate that controls the occurrence of the life form of the dominant species and which in turn become the characteristic appearance of that climax community. That's why this theory is also known as '**Climatic climax theory'**. Given sufficient time, all seral communities in a region, be it aquatic system or terrestrial ecosystem, will converge to and stabilize at a single climax i.e. whole landscape will be with uniform plant community and will overcome all the effects of differences in topography, edaphic factors and other factors. According to this theory communities other than the climatic climax are considered as seral stages.

Clements also proposed four different terms to describe the occurrence of more than one stable and self-perpetuating community in a given climate, which may be different from climatic climax, but related to the climax by successional development and are described as:

(i) **Preclimax**: A stable and self-perpetuating community i.e. climax community when occur in an area which is dry or more xeric than the general conditions of the region or general climates of the region is described as Pre-climax community.

(ii) **Postclimax**: A stable and self-perpetuating community when occur in an area which is comparatively more moist compared to general features then it is described as Post climax.

(iii) **Subclimax:** A stable and self-perpetuating community in an area when occur due to peculiarities in the physiographic or edaphic conditions indicating the arrest of succession, is known as 'Sub climax'. However, after a long period of time the subclimax has the potential to change into climatic climax.

(iv) **Disclimax:** When the climatic climax is replaced by a self-perpetuating and relatively stable community due to recurring biotic interferences then such climax is described as Disclimax.

(II) PolyClimax Theory:

Polyclimax theory was proposed by Tansley (1935) to describe the occurrence of several climax communities in a region forming a mosaic of vegetation climaxes which are regulated either by soil moisture, soil nutrients, topography, fire or biotic activity. According to this theory it is the spatial patterns or heterogeneity of habitats that influences the spatial pattern i.e. the mosaic of climax communities. To describe the existence of climax communities under different habitats, Tansley recognized following five different types of climaxes, some of these are primary climaxes whereas others are secondary climaxes:

(i) **Climatic climax**: Climax community which exists under normal climatic conditions in absence of any form of disturbance is described as Climatic Climax.

(ii) **Edaphic Climax**: When stable and self-perpetuating communities develop in parts of the same area due to peculiarities in soil i.e. variation in edaphic factor and are different from climatic climax, then they are described as Edaphic climax.

(iii) **Topographic climax**: Differences in topography may give rise to different local micro-climates, each of which in turn can support a self- perpetuating and stable community then such climax communities are explained as Topographic climax.

(iv) **Fire climax**: When climax community occur in response to recurrent burning of vegetation which eliminate the fire susceptible species, then such climax community is known as Fire climax.

(v) **Zootic Climax**: When climax community occur in response to recurrent biotic factor (e.g. grazing by cattle) then such climax community is known as zootic climax

(i), (ii), and (iii) are considered as primary climax whereas (iv) and (v) as secondary climaxes. Secondary climaxes i.e. (iv) and (v) are similar to Clements's Monoclimax hypothesis.

(III) Climax Pattern Theory or Population Pattern Theory:

Whittaker (1953) rejected classification approaches of describing climax and proposed 'Climax pattern theory' which is based on a combination of the continuum/gradient concept and the individualistic concept of the plant association. That is the reason why this theory is also known as 'Population Pattern Theory'. He believed that since species composition and the balance of the climax community is determined by the total environment (including both biotic and abiotic factors/conditions) of the ecosystem, any change in the environment will result into the mosaic of climax vegetation. The climax community represents a pattern of populations that corresponds to the changes with the gradients or patterns of environment to form ecocline. According to this theory the communities that occupy the largest area in this ecocline are known as the ‘Prevailing climax’ or climatic climax. This theory recognizes a spatial pattern of climax vegetation which reflects the spatial variation in the environmental conditions at that point. There is thus no discrete number of climax communities and no one factor determines the structure and stability of a climax community.

According to monoclimax theory only one climatic climax can exist in a region whereas as per polyclimax theory several climaxes may develop depending upon the habitat heterogeneity. The climax-pattern theory on the other hand, describes a continuity of climax types varying gradually along environmental gradients and not clearly separable into discrete climax types.

Examples of Succession

I Hydrosere or Hydrarch

Succession that starts from an aquatic ecosystem e.g. ponds, pools or lakes is known as Hydrosere. After the exposure of water body which are clear, poor in nutrients and devoid of much life and thus incapable of supporting any life form. The hydrosere started with pioneer plant community, generally consisting of phytoplanktons, through various seral stages, terminated in forest as climax community. Changes occur both in plant community as well as in animal community during the course of succession. Below is the example to describe the various seral stages of hydrosere starting from an aquatic habitat of the dry tropical regions.

(1) Phytoplankton stage:

Pioneer colonizers are phytoplankton i.e. microscopic algae, diatom and bacteria etc., which colonizes the primitive medium of ponds. They multiply and colonize quickly. Some microorganisms, like bacteria and fungi feed on these phytoplanktons also colonize there. The phytoplanktons and these microorganisms, after their death, decompose and result in the release of minerals which in turn will mix up with the silt, brought from the surrounding land by rain water and by wave action of pond water. These autogenic influences resulted in development of soft mud at the bottom of pond and enrichment of aquatic habitats which now can support different types of organisms

(2) Submerged stage:

This new habitat which tends to be a little shallower allows penetration of light on the shallow regions become more suitable for the growth of rooted submerged hydrophytes, first by deep water submerged hydrophytes e.g.*Potamogetonsp, Nitella sp. Chara sp.* etc. followed by shallow water submerged hydrophytes e.g.*Ceratophyllumsp*, *Hydrilla*sp etc. Some small animals will also invade and colonize. These plants and animals brought about further buildup of the substratum as a result of their death and decay.

The depth of water level decreases therefore pond become less deep or more shallow, turbid and nutrient rich. This creates a new habitat which will replace these plants by more nutrient demanding floating hydrophytes.

(3) Floating stage: Two different forms of floating hydrophytes will represent this stage first by rooted floating hydrophytes which will be followed by free floating hydrophytes.

(a) Rooted Floating Stage:

Deeper zones are occupied by such species which are rooted in mud but whose leaves reach the water surface and float e.g. *Typha* sp., *Nelumbo* sp., *Nymphaea* sp., Monochoriasp.,etc. The floating leaves on the surface of water body will transpire water. Gradually with evaporation of water, the concentration of nutrients increases and become sufficient to support free floating species which are not rooted in mud.

(b) Free Floating Stage: Free floating plants e.g. Lemna, Wolfia, Azolla, Pistia, Salvinia etc. floats freely on the water surface having no contact with mud of pond but the upper surface of leaves are in contact with air, colonize and gradually cover the water surface. Water level decreases further therefore pond become more shallower. Decomposing organic matter due to death and decay of these plants further build up more substratum. The floating leaved communities cast shade on their predecessor submerged communities and eliminate them by creating a deficiency of light. The raised bottom level is invaded by next seral community.

(3)Emergent Anchored Hydrophytes stage:

Pond margins, because of good environmental conditions of high moisture, enough light and aeration soon gets covered by emergent hydrophytes e.g. *Typha* sp., *Sagittaria* sp. etc. Although their root system is completely under water and anchored in soil but their shoots are partly or completely exposed to air, so are like amphibian plants. They have well developed rhizome and form very dense vegetation. These plants start from margins and then cover the pond. These plants facilitate considerable decrease in water level resulted in change in substratum which in turn changed the aquatic habitat into marshy land or swamp. This stage is often known as 'Red swamp stage'.

(4)Sedge Meadow Stage: With change in the nature of substratum to swamp, members of family Cyperaceae and Poaceae (*Carex* sp., *Juncus* sp., *Cyperus* sp., *Eleocharis*sp.etc) invaded and form a mat like vegetation with the help of their much branched rhizomatous systems. As a result of high rate of transpiration much rapid loss of water occurs and thereby mud is exposed to air. This resulted in change in the nutrient status e.g. from NH_4^+ to NO_3^-. The area will become more mesic and this resulted in disappearance of marshy vegetation.

(5)Grassland stage or Woodland stage

Soil becomes drier for most part of the year with much accumulation of humus, rich in nutrients facilitated the invasion of terrestrial plants, first herbs then shrub and finally trees.

(6) Forest stage: Depending upon the climate the climax will be rain forest, temperate forest or tropical forest.

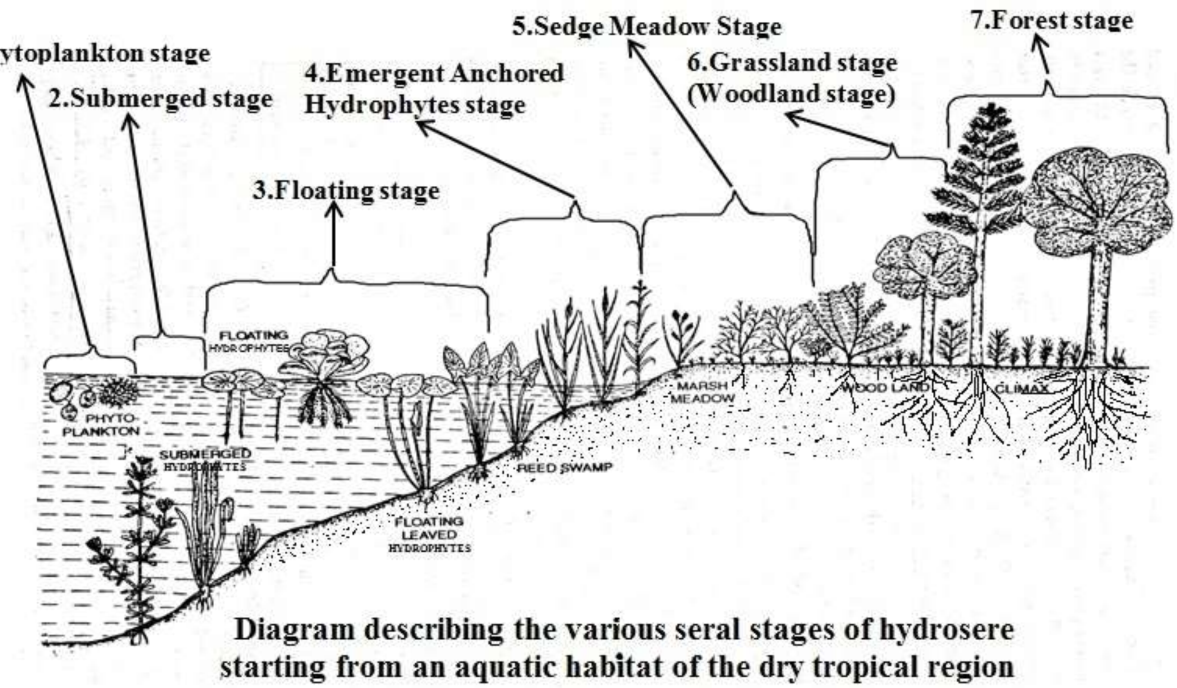

Diagram describing the various seral stages of hydrosere starting from an aquatic habitat of the dry tropical region

II Xerosere or Xerarch

When succession begins on any kind of dry habitat it is known as Xerosere. Since dry habitat may be of different type so the consequent succession may be of the following types:

S.No.	Type of habitat	Name of consequent succession
1	Sand	Psammosere

2	Rock	Lithosere
3	Highly saline (physiologically dry)	Halosere

Below is an example of lithosere of tropical region. Successional trend is governed by the process of soil formation and accumulation. Bare area i.e. rock, faces scarcity of water, lacks any organic matter with disintegrated unweathered nutrients. Organisms which can survive in these harsh conditions can colonize such habitat as pioneer community. Pioneer community is generally represented by Crustose lichens whereas the climax community by forest.

(1) Crustose lichen stage:

Crustose lichens e.g. *Rhizocarpus, Rinodina*and*Licanora*, since can grow and multiply in these harsh conditions, form crusts on the dry rock and remain in a dormant condition for very long time. They produce some carbonic acids which bring about wreathing of rocks in form of cracks or roughen the rock surface. They may absorb water from rain and dew-drops which wet their external surface. In the space, thus created, dust and dead organic material of these lichens accumulate and provide space and growth condition for the next higher life forms to invade.

(2) Foliose Lichen stage: The habitat thus created is now suitable for the growth of foliose lichens e.g. *Parunetia*, *Dermatocarpon* etc. Foliose lichens have leaf like thalli, can absorb and retain more water and are able to accumulate dust particles. The habitat will now become unfavorable for the growth of crustose lichens as foliose lichens cast shade on them. Foliose lichens also produce some acids which not only make the soil acidic but also facilitate weathering of rocks. Some microorganisms like bacteria and fungi appear along with few small invertebrate animals which also become associated with lichens. Humus is added through the decomposition of the dead lichens and other organisms. All these processes stimulate the formation of thin layer of soil on rock surface especially in crevices.

(3) Moss stage:

Development of some xerophytic mosses e.g. *Polytrichum*sp, *Tortula*sp and *Grimmia*sp on cracks and crevices occurred. Mosses outcompete lichens as the former having rhizoids can penetrate much deeper in the soil as compared to the latter. Later on, small mosses were replaced by bigger hydrophytic mosses like *Funaria*sp, *Sphagnum* sp,*Polytrichum* sp. Several small animals mostly arthropods like spiders, mites, etc. also inhabit there. Mat of mosses can accumulate water, so moisture status of the habitat improves drastically. All these changes result in increase in soil layer, more accumulation of organic matter, addition of minerals to soil as acid leaches out, which in turn make the habitat suitable for the next seral community.

(4) Pteridophytes stage:

Availability of moistures, humus and soil for anchorage facilitate the colonization of pteridophytes e.g. *Selaginella*sp, *Adiantum*sp etc. These plants increase the process of weathering. Biological activities, rapid decomposition of organic matter and more soil accumulation and moisture status create conditions for growth of herbaceous of plants.

(5) Herb stage:

Ferns are now replaced by many aggressive weeds and hardy grasses. First annual weeds colonize which are then followed by biennial and finally perennial grasses. Members of family

Poaceace and Graminae dominates, the common examples are Poasp, *Artistida*sp, *Andropogon*sp, etc. With the growth of grasses and forbes, transpiration takes place which reduces the prevailing temperature. In addition to micorganisms and several invertebrate animals like arthropods, nematodes, annelids, etc., vertebrate animals also appear and gradually modify the habitat.

(6) Shrub stage

Further alteration of the environment especially conditions of soil provides conditions for the establishment of shrub followed by small woody plants such as *Acacia* sp, *Prosopis* sp, *Capparis* sp, *Zizyphus* sp etc. They grow densely and cast shadow on herbs. Now the habitat will become more favourable for the growth of shrubby vegetation compared to herbaceous vegetation. The dead and decaying herbaceous plants help in addition of considerable amount of organic matter into the soil. With extensive root system, shrubs penetrate into soil and develop wide cracks in rock, and thus stimulate the process of soil formation. Rate of transpiration increases which result in moderation of temperature and increase in humidity. All forms of vertebrates will now become associated with this altered vegetation.

(7) Forest stage

The increase in the soil depth, moisture content, nutrient availability, soil organic matter and significant moderation of environment, favours the growth of woody trees. Sparsely distributed woody trees with stunted growth in the beginning dominate the habitat which over period of time was then replaced by deeply rooted dense tall trees. Finally a climax forest community is established with stratification of vegetation represented by short trees, shrubs and various forms of herbaceous ground vegetation along with various forms of animals. This stage essentially remains the same until no major change in the environment occurs.

Within the same broad climatic belt, seral stages starting in water and on rock lead to the same type of climax community.

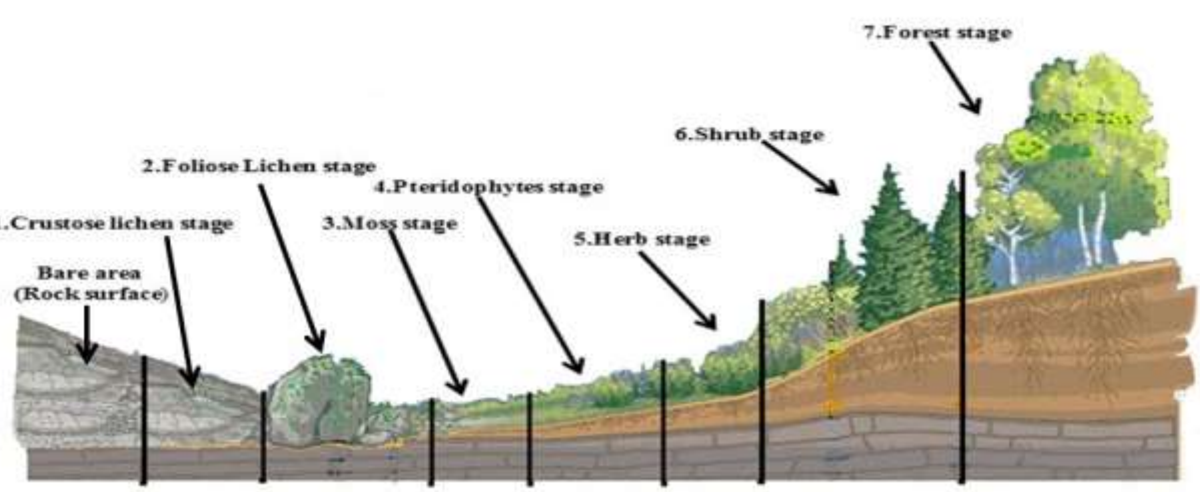

Diagram describing the various seral stages of lithosere starting from bare area (rock surface) in the dry tropical region