

ECOLOGY

By Tr. Eliya

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By the end of this topic, the learner should be able to;

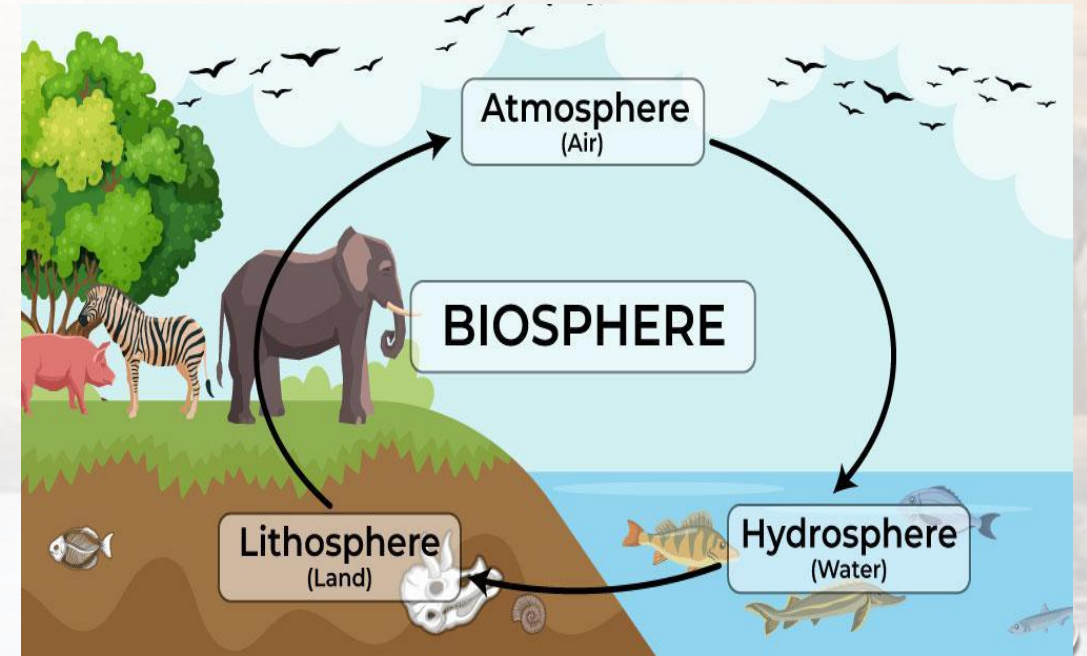
- a) Analyse population dynamics and the factors affecting them in different ecosystems.
- b) Analyse the processes of ecological succession and strategies for effective ecological restoration practices in diverse environments
- c) Examine the concept of energy flow through ecosystems, its role in maintaining ecosystem stability, and the impact of human activities on energy flow.
- d) explain the concept of carbon footprint in relation to climate change, including its measurement, as well as the role of carbon sequestration in mitigating climate change.
- e) Examine the impact of invasive species on native biodiversity, ecosystems, and economies, as well as strategies for their management and control.
- f) Analyse the concept of food security, focusing on its components and sustainable agricultural practices to address its challenges.

WHAT IS ECOLOGY

- **Ecology** is the scientific study of interactions of organisms with each other and with their surroundings, the environment. It is called **environmental biology**.

KEY TERMS

- **Biosphere:** Is the part of the earth occupied by living organisms is called the biosphere. The biosphere extends from the bottom of the oceans to the upper atmosphere, The biosphere is sub divided into biomes



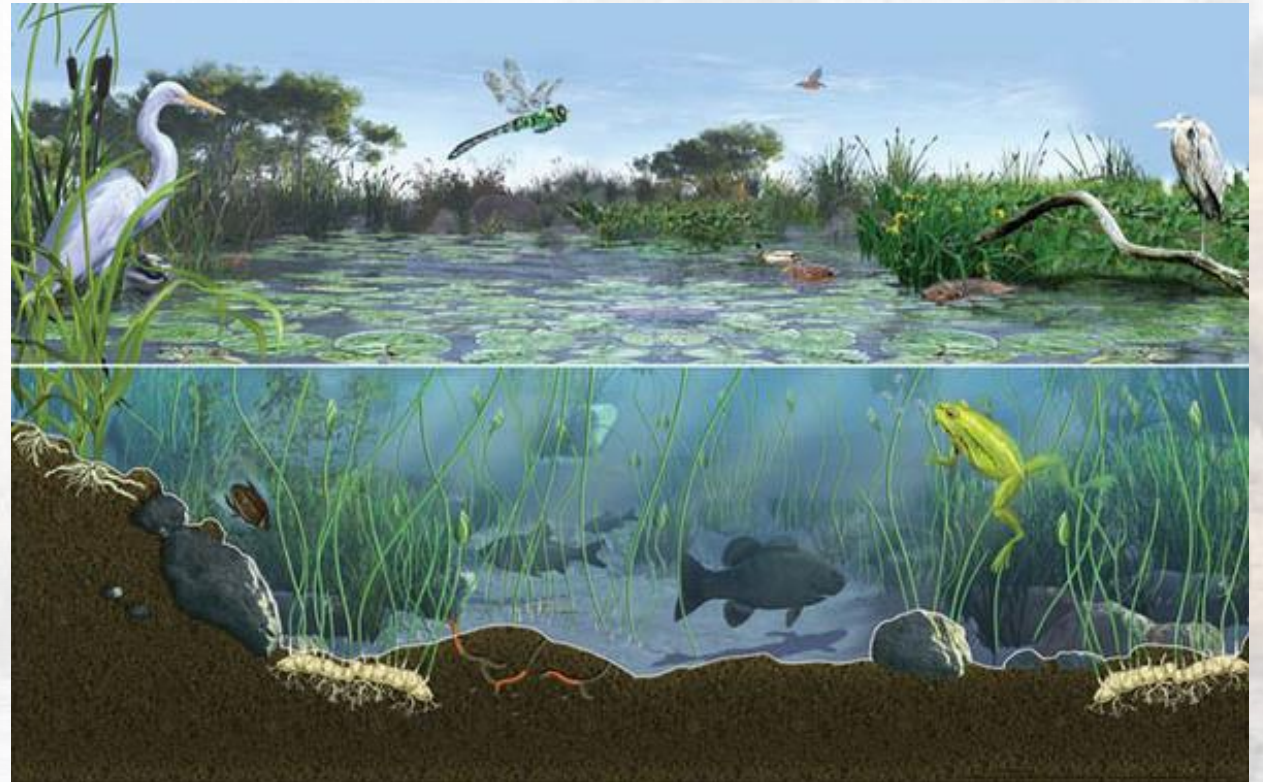
- **Biomes:** These are biogeographical regions of the biosphere each inhabited by distinctive species of animals and plants. e.g. Tropical forests, savannah, deserts etc. Biomes are also sub divided into zones e.g forest biome has ground zone, canopy zone etc. Within each biome are numerous **habitats**



- **Habitat:** Is the area in which an individual lives. If the habitat is very small, it is called a **microhabitat**. Microhabitats are smaller units of a habitat each with its own **microclimate** e.g the mud at the bottom of the streams is a microhabitat for worms. Most ecosystems contain several habitats. (B. in context 338)



- **Ecosystem** is a self sustained community of organisms and their physical environment interacting as an ecological unit. E.g a pond



- **Community:** Is a group of populations of different species which live in the same place at the same time and interact with each other.



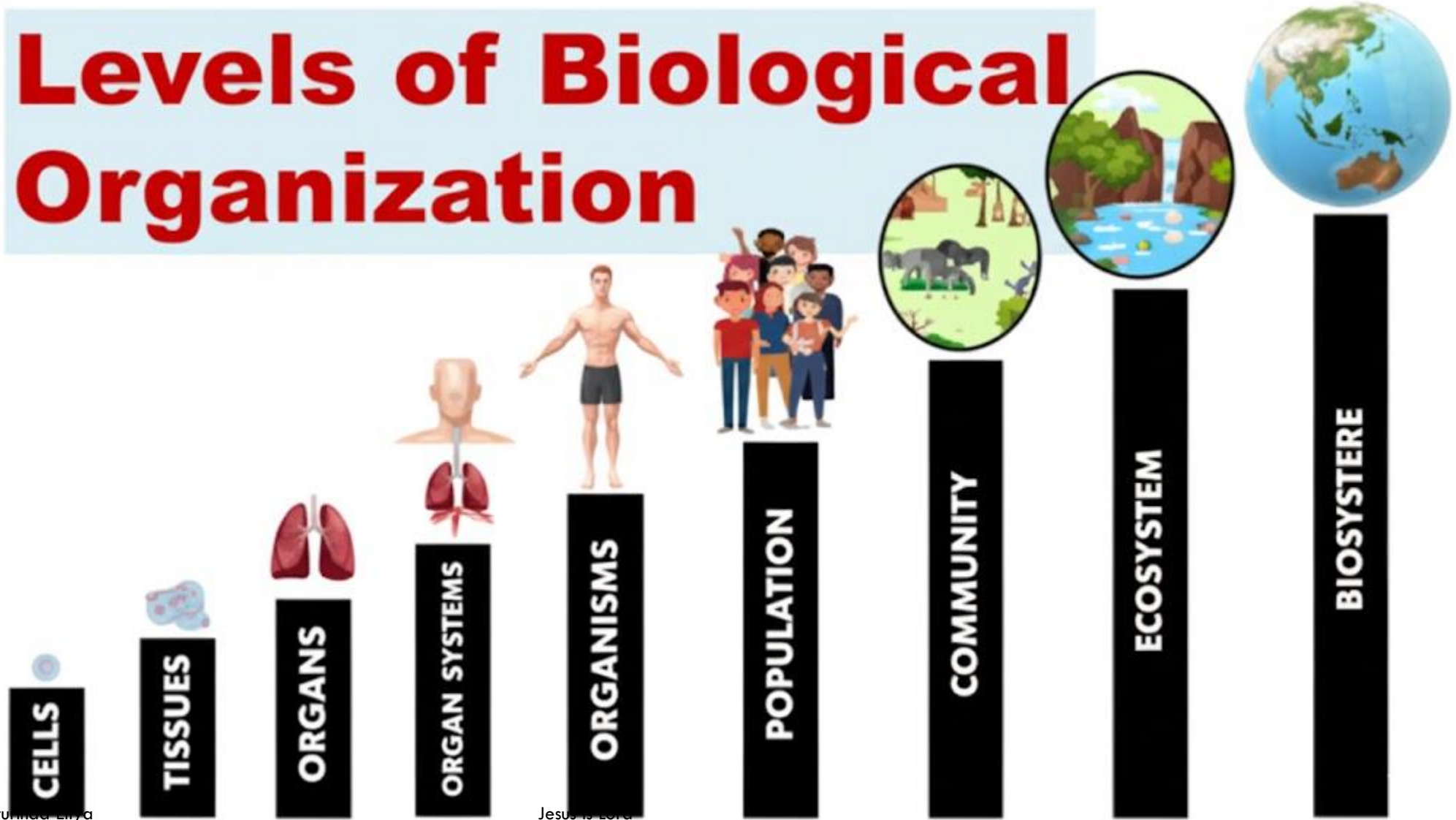
- **Population** is a group of individuals of the same species which live in a particular area at any one time.



- **Ecological niche** is the ecological role of a species within its community and its habitat.



Levels of Biological Organization



COMPONENTS OF AN ECOSYSTEM (UB 343)

- The components of an ecosystem are divided into two i.e
 - a) Biotic (living) components
 - b) Abiotic (non-living) components

Biotic components

- These are components of the ecosystem as a result of activities of living organisms for example competition, Predation, antibiosis, dispersal, pollination, mimicry, human influence. (Make notes (definition and examples) about each from UB. 343)
- **Assignment.** Read and make notes (definition and examples) about symbiosis (associations between organisms i.e parasitism, commensalism and mutualism from F.A 544)

Abiotic components.


- These are non living parts of the ecosystem. They can be
 - a) Climatic such as light, temperature, water availability, and wind.
 - b) Edaphic i.e associated with the soil, such as its texture, pH, temperature, and organic content
 - c) Topographic such as the angle and aspect of a slope.
- **NB;** All these abiotic factors interact with each other and with the biotic component, the organisms living in the ecosystem.

POPULATION DYNAMICS

- **Population dynamics.** Is the study of how and why population size changes over time.
- **A population** is a group of organisms of one species occupying a particular place and usually isolated to some extent from other similar groups by geography or topography. Bs 321

Important population characteristics include: Bs 321

- Density,
- Natality (birth rate),
- Mortality (death rate),

- 
- A savanna landscape with a watering hole. In the foreground, several elephants are gathered around the water. In the background, a herd of zebras is visible. The sky is bright and hazy. There are decorative bubbles in the corners of the slide.
- Survivorship,
 - Age structure,
 - Migration
 - Growth form of the population.

- **Natality** (Birth rate), the number of young produced per female per unit time (usually per year).
- **Mortality** (rate of death) is the per cent, or numbers per thousand, dying per year.
- **Migration** is the movement of organisms of a population from one region to another.



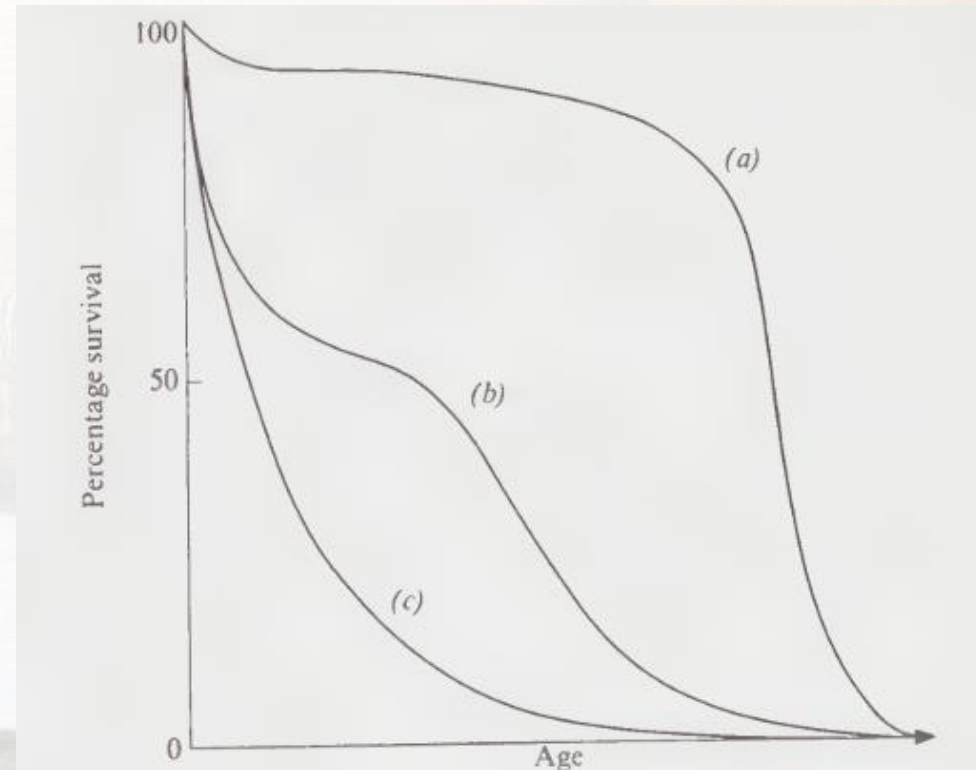
NB; Environmental factors affect population size by affecting the above characteristics i.e

- Population size may increase as a result of **immigration** (movement into the population) from neighbouring populations, or when birth rate is higher than death rate.
- Population size may decrease as a result of **emigration** (movement out of the population) or when death rate is higher than death rate.

SURVIVORSHIP

- Survivorship is the variation of numbers of survivors of a population of newborns with age.

Survivorship curves



Graph (a)

- Is for a population in which senescence (ageing) is the mayor factor affecting mortality. Senescence leads to an increased likelihood of death due reduced resistance to external factors such as disease. e.g. for an annual crop plant such as wheat, where all the plants in a given field survive well early in life and then senesce simultaneously.



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Graph (b)

- is for a population with a high mortality rate early in life, such as might occur for mountain sheep or for humans in a country in which starvation and disease are prevalent.



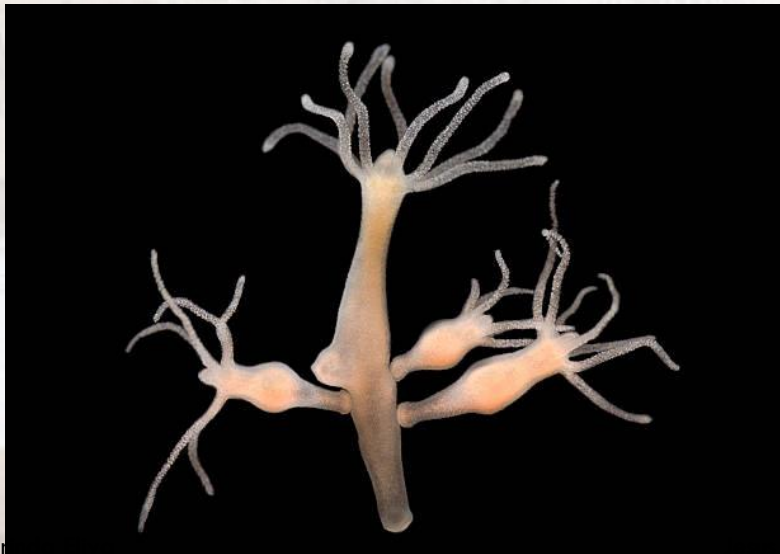
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Graph (c)

- Shows the kind of smooth curve obtained if there is a constant mortality rate throughout life (50% per unit time). Such a curve is obtained if chance is the major factor influencing mortality other than senescence or special risk attached to being young. For example Hydra,



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POPULATION GROWTH

- **Population growth** is a change in the number of individuals; this is referred to as **positive growth** when the numbers increase and **negative growth** when they decrease. (Michael Kent pg 514)
- **Population growth rate**: the change in number of individuals per unit time; again, this may be positive or negative.
- **Population density**: the number of individuals per unit area



- The size of population increase depends on the reproductive potential of the organisms concerned and the environmental resistance.

Biotic potential vs environmental resistance

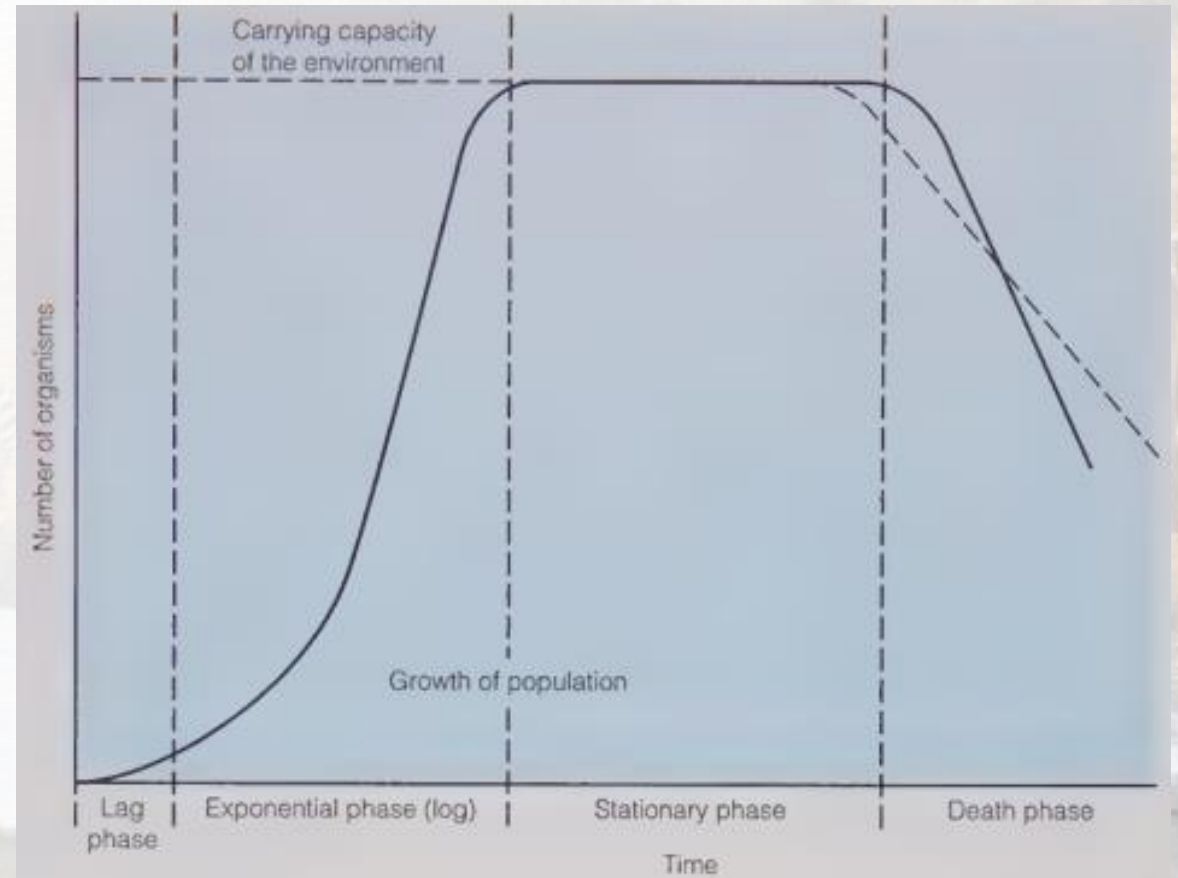
- The maximum reproductive potential (**Biotic potential**) is the rate of reproduction given unlimited environmental resources.
- **Environmental resistance** means the sum total of factors, both biotic and abiotic, that limit the size of a population.

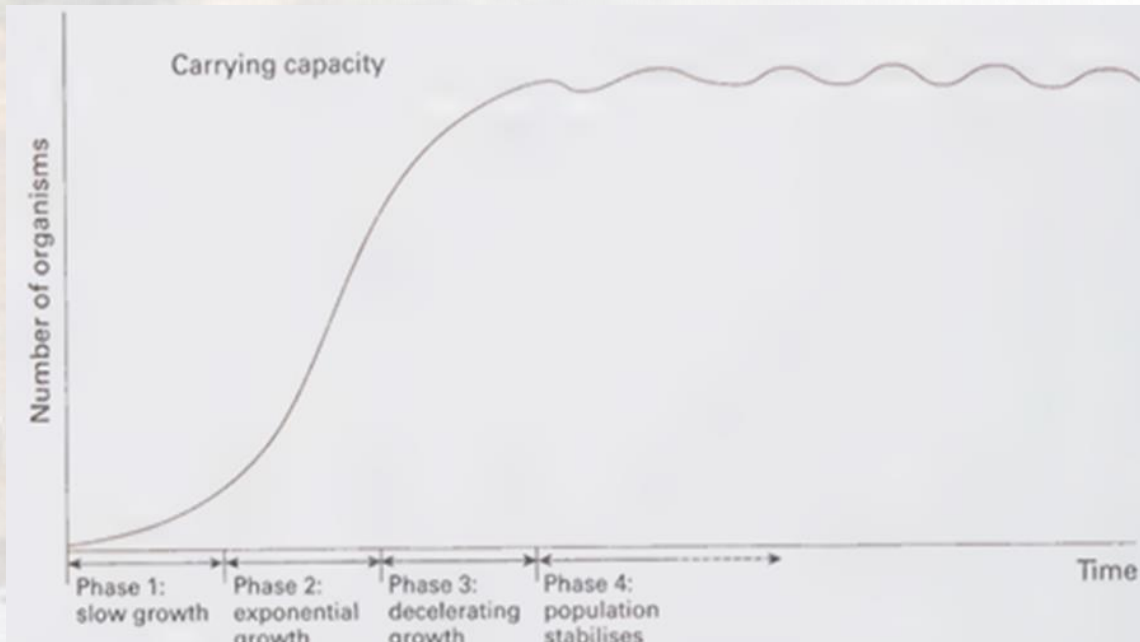
GROWTH CURVES

Two basic forms of growth curve can be identified,

- The J- Shaped growth curve and
- The S-shaped or sigmoidal growth curve.

The S-shaped or sigmoidal growth curve. ('sigma' is the Greek word for the letter 's').





Lag phase

- The population of an organism increases slowly initially, as it is still adapting to new conditions and establishing itself in the new environment and there are few reproducing individuals.

Log phase

- The population increases rapidly, it doubles its number at a given time; more individuals become available for reproduction. There are no factors limiting growth i.e nutrients, oxygen are plentiful and there is ample space (Simpkins 656). **NB:** It is called log phase because a straight line is obtained if logarithm of number of organisms is plotted against time during this phase.

Linear phase (Glenn 68)

- The population increases gradually. The slowing rate of population growth is because environmental resistance sets in hence increased competition for essential resources, such as food or nesting materials, a build-up of toxic chemicals produced by the organisms.

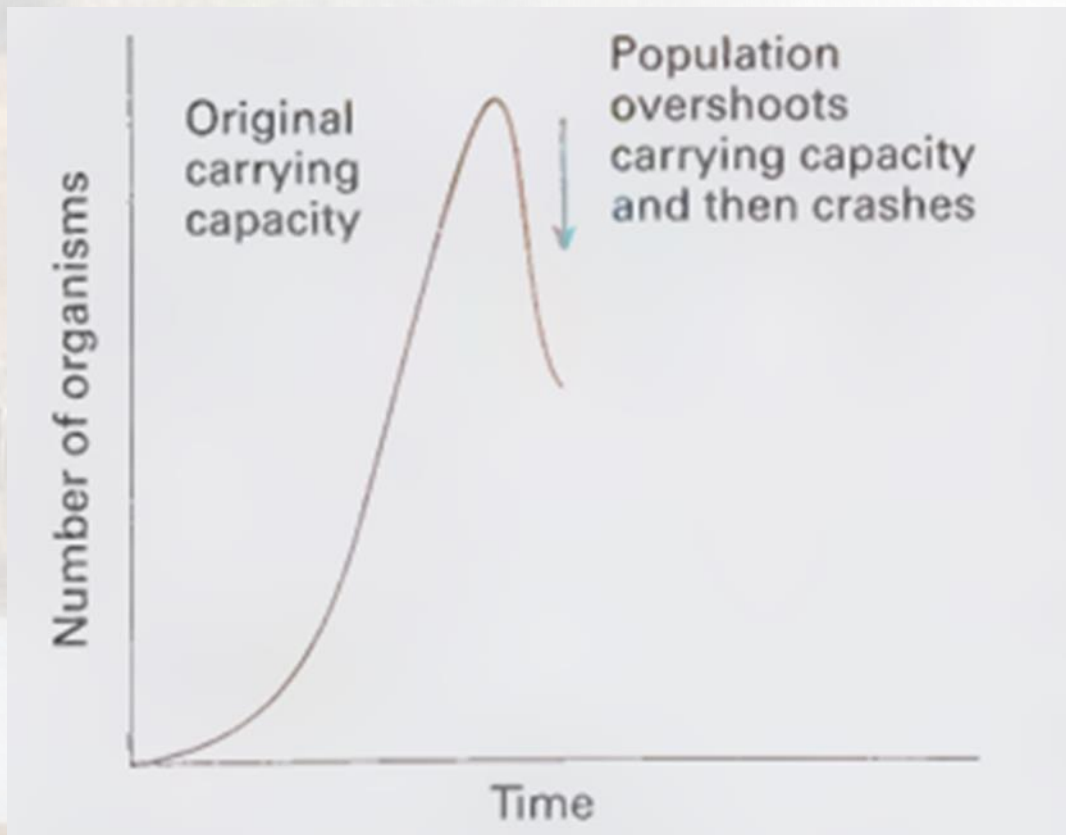
Stationary phase

- The population size is constant. The population is stable and does not increase further, Birth rate and death rate exactly balance each other. This is because the environment has reached the **carrying capacity**. The environmental resistance is in equilibrium with reproductive potential.
- **NB; Carrying capacity** is the maximum population size the environment can support for a relatively long time.


Death phase

- The population size decreases. The large population size causes the carrying capacity of the environment to decline. The environment is unable to support such a high number of organisms and they begin to die.
- **NB:** Usually the population continues fluctuating around the carrying capacity. This is due to variations in climatic conditions (such as temperature), food supply and predation. Sometimes fluctuations are regular and may be called cycles.

The J-shaped growth curve (Boom and burst)



- A population increases so rapidly during the exponential growth phase that it overshoots the carrying capacity.

- 
- As the environment cannot support the population, a population crash follows. Overpopulation can damage the environment, leading to a new, lower carrying capacity.
 - The crash may also be triggered by factors such as seasonality or the end of a breeding phase, or seed production, or use of insecticides to reduce insect pest population. Bs 323

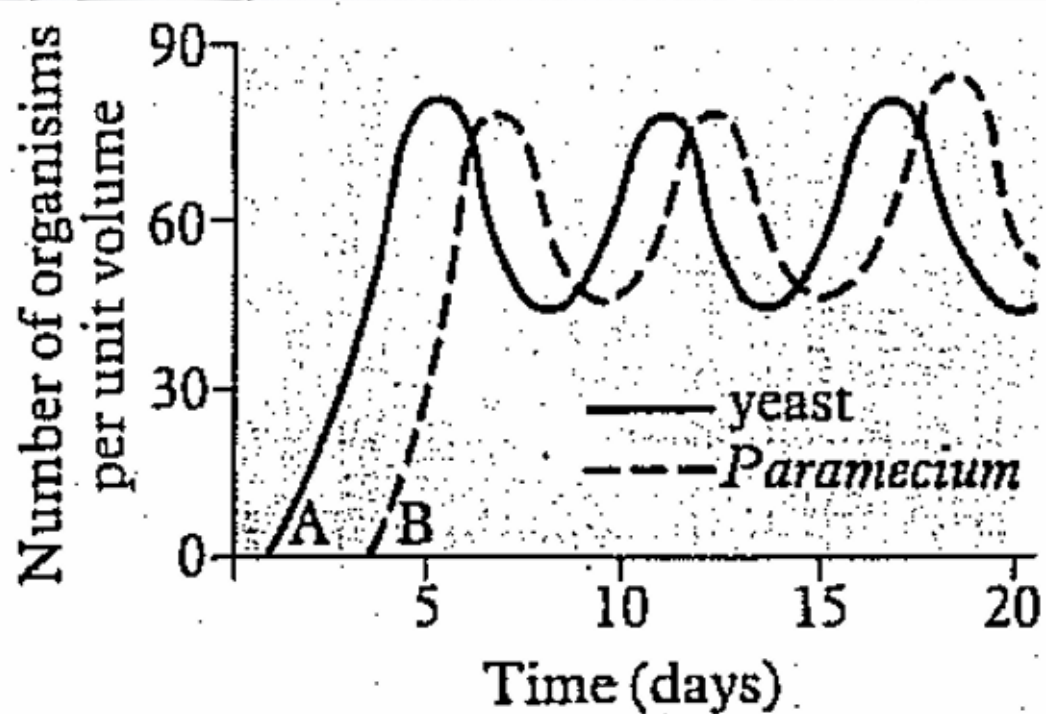
PREDATOR-PREY RELATIONSHIPS

- **Predation** refers to when an organism may feed or be fed on by another organism. The predator is the organism which feeds on while the prey is the organism fed on.



Predator-Prey curves.

- These curves show cyclic fluctuations. The fluctuations of the predator lag behind those of the prey. The explanation for these cycles is that an increase in numbers of the prey supports a subsequent increase in numbers of the predator. The predators then cause a crash in numbers of the prey, followed by an inevitable decline in numbers of predators. The cycles are completed when the decline in predators allows an increase in numbers of the prey. Bs 324



- NB;** Predation and competition are important factors in regulating natural populations i.e keeping them at the carrying capacity and the set point. If the population rises above the set point, competition or predation takes place to such an extent that the population falls. If it falls below the set point environmental resistance is temporarily relieved so that the population rises again like a negative feedback homeostatic control. (FA 527, BS 324)

FACTORS AFFECTING POPULATION DENSITY M. Kent 515

Biotic factors. These result from the activities of living organisms. these factors have stronger effects as the population density (number of organisms in a given space) increases, they are therefore **density-dependent factors**.

- **Space:** Plenty of suitable space available increase population size in a given space. Unavailable or limited suitable space decrease population size. Space provides breeding spaces , and prevents overcrowding which affects reproductive rate as a result of hormonal changes leading to failure to copulate, infertility, number of abortions and eating of young by the parents all increase, and parental care decreases.

- **Food supply:** Good food supply increases population size. Inadequate food supply decreases population size. Lack of food leads to starvation and death.
- **Water supply:** Good water supply increases population size. Inadequate water supply decreases population size.
- **Disease:** Low disease prevalence or ability to resist disease increases population size. High disease prevalence or inability to resist disease decreases population size.
- **Predation:** Small number of predators (low predation) or ability to avoid predation increase population size. High predation or Inability to avoid predation decrease population size.

- **Reproductive rate:** High reproductive rate increases population size. Low reproductive rate decreases population size.
- **Human influence:** intense human activities may severely decrease or wipe out the population of certain organisms e.g. hunting, fishing, clearing land for settlement and industrialization. Where humans are not, the population of such organisms affected such as trees, animals which inhabit the forests is high



Abiotic factors: These are as a result of the non-living part of an ecosystem.

• These factors affect the same proportion of the population no matter what its density. Therefore called **density-independent factors**

• **Light:** Favourable light increases population size. Too much or too little light decreases population size. Light is important for photosynthesis a primary source of food.

• **Temperature:** Favourable temperature increases population size. Too much or too little temperature decrease population size. The temperature range within which life exists is relatively small. Temperature affects most importantly enzyme activity and structure of proteins. At low temperatures ice crystals may form within cells, causing physical disruption, and at high temperatures enzymes and other proteins are denatured.

- **Humidity:** moderate humidity increases population size. Very high or very low humidity decreases population size. Humidity affects the rate of transpiration in plants and so affects their distribution. it affects the distribution of some animals by affecting the rate of evaporation from their bodies.
- **Air and water currents:** Stable currents increase population size while unstable currents decrease population size. Air and water currents affect organisms indirectly, for example by evaporative cooling or by a change in humidity. Wind is an important mechanism for dispersing seeds and spores. Water currents determine species distribution in aquatic habitats.



ESTIMATING POPULATION DENSITY

- Population density is estimated because it is virtually impossible to identify and count every organism in a habitat. For this reason only small sections of the habitat are usually studied in detail.
- The exact methods used depend not only on the nature of the habitat but also on the organism involved e.g. the motility of the organism. In this subtopic we shall focus on two techniques i.e
 - a) The quadrant technique
 - b) The capture-recapture technique.

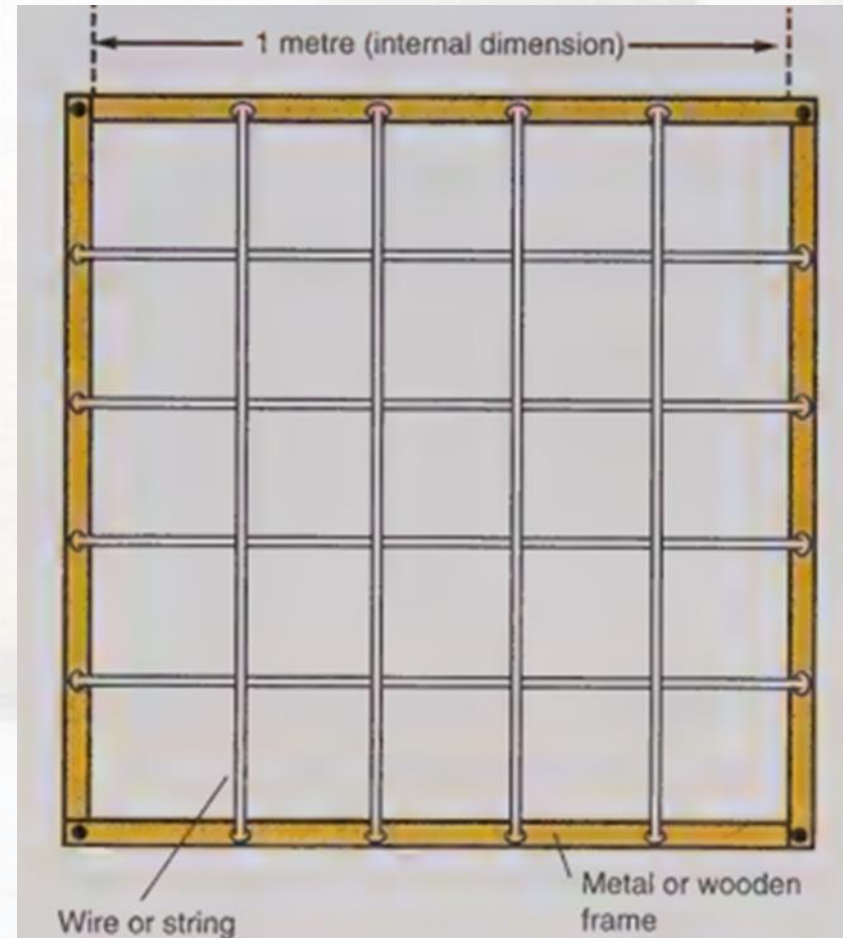
QUADRANT TECHNIQUE

- A quadrat is a sturdily built wooden frame, often designed so it can be folded to make it more compact for storage and transport.
- The quadrat method is used on static (non motile organisms) or very slow moving organisms.

Procedure

- It is placed on the ground and the individuals of a particular species present within the frame are then counted.
- The procedure is repeated with the quadrat in different places, and the average number of individuals per unit area is calculated.
- The quadrat density is therefore converted to the total area being investigated.

- **NB;** Where the species are small and/or densely packed, one or more of the smaller squares within the frame may be used rather than the quadrat as a whole.



- Sampling with a quadrat may be

- a) random or
- b) systematic.

a) Random sampling

- This can be as simple as throwing a quadrat over one's shoulder and counting the species within it wherever it falls.

b) Systematic sampling

- This involves placing the quadrat at regular intervals, for example, along a transect.



Figure 2 Ecology student using a quadrat

THE CAPTURE-RECAPTURE TECHNIQUE.

- This is also called **Capture, mark, release and recapture method**.
- The capture-recapture method of estimating the size of a population is useful for mobile animals. Most animals are mobile and move away when approached. They are often hidden and therefore difficult to find and identify hence the quadrant method is not suitable for them.
- **Procedure**
- A known number of animals are caught, clearly marked and then released into the population again.
- Some time later, a given number of individuals is collected randomly and the number of marked individuals recorded.
- The local population is estimated using the formula

$$\text{Population} = \frac{n1 \times n2}{n3}$$

n1 - numbers captured, marked and released

n2 - total number of individuals recaptured

n3 - number of marked individuals recaptured.

- **NB:** This estimate of population is known as the **Lincoln Index**.
- In using the capture-recapture method, however, certain assumptions have to be made.

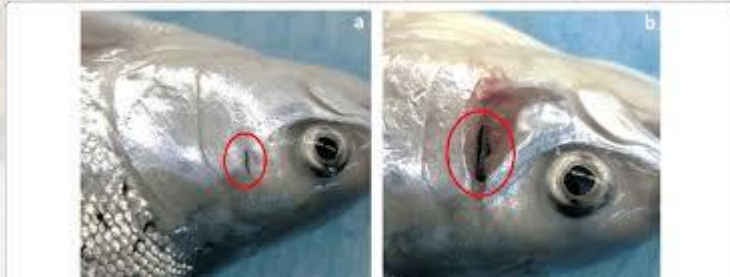
Assumptions of capture-recapture method

- The proportion of marked to unmarked individuals in the second sample is the same as the proportion of marked to unmarked individuals in the population as a whole

- The marked individuals released from the first sample distribute themselves evenly among the remainder of the population and have sufficient time to do so
- The population has a definite boundary so that there is no immigration into or emigration out of it
- There are few, if any deaths and births within the population
- The method of marking used is not toxic to the individual, nor does it make the individual more conspicuous (easily seen) and therefore more liable to predation
- The mark or label is not lost or rubbed off during the investigation

Different ways of marking organisms

- Fish; their operculum tagged with aluminium discs;
- Birds; rings attached to their legs;
- Small mammals may be tagged by dyes, or by clipping the fur in a distinctive pattern;
- Arthropods are marked with paint.



SUCCESSION

- **Succession** is the sequence of change of communities, from the initial colonisation of a new area to establishing a relatively stable community,
- Typically communities evolve from simple and gradually become more complex
- There are two main types:
 - I. primary succession
 - II. secondary succession.
- NB: Ecological succession happens in stages called seres or seral stages; each stage has its own community of organisms, and can usually be identified by the plants it contains.

PRIMARY SUCCESSION.

- Is the type of succession which happens in a newly formed area where no life previously existed, for example, volcanic islands, glacial deposits of rock, new ponds or lakes, and sand dunes

Process of succession on rock

- The initial rock surface presents a hostile environment for most living organisms. Early colonisers will need to be autotrophs which can tolerate these hostile conditions, also with good dispersal mechanisms to ensure arrival at the site. Typical organisms are lichens, algae and blue-green bacteria. The first organisms to bring about colonization of a new area, are called **pioneers (pioneer community)**

- Lichens, for example, exude chemicals which help to break down the rock surface, at the same time supplying themselves with essential inorganic materials. When they die, these primary colonisers provide DOM (Decaying organic matter) which accumulates in the small depressions and cracks in the rock.
- This debris is a good food source for decomposers and marks the beginning of soil formation and accumulation of readily available nutrients for plant growth. This soil formed provides a foothold for mosses and later ferns and grasses.

- With the further breakdown of the rock and build up of humus, a thicker layer of soil is built up, various herbaceous perennials and later on shrubs take root. In the course of time trees move in. Organisms which colonise the area later after soil formation by the pioneers are called **opportunists**.
- As new plants move in and develop, so too the animal species change. Ecological succession leads to a **climax community**.
- **Climax community** is defined as the most complex, species rich and relatively stable community which is in equilibrium with its environment.

- **NB:** At the climax community, there is no further influx of new species to replace those already established.
- At each stage in this gradual evolution, a dominant species can be recognized. The **dominant species** is the most prominent species and one with the greatest biomass of a given seral stage. Sometimes there are two or three codominant species.



SECONDARY SUCCESSION

- Is the type of succession which occurs during the recolonization of an area previously occupied by a community which has been partially or completely destroyed for example by a natural disaster such as a fire or human interference such as ploughing a field. FA 530
- In these circumstances the succession will not begin with pioneer species but with organisms from subsequent successional stages. The changes are similar to those in primary succession on a rock but the process is usually faster as soil, often containing seeds and spores, is present. M.Kent 522, UB 361

Process of secondary succession on fire burnt site.

- The first plant on burnt wood ash is the moss, which forms extensive carpets. Within the moss carpet the seeds of herbaceous and woody plants lodge and germinate.
- A new herbaceous layer grows, followed by shrubs and trees. Each dominant plant community has associated with it various animal populations.
- **NB:** Due to constant burning, grazing or some other factor prevents the secondary successions from reaching their climatic climax. Instead they reach sub climax called **plagioclimax** e.g. heaths and grasslands (UB. 361).

- **Plagioclimaxes** are relatively stable plant communities arising from succession that has been deflected or arrested (**deflected succession**), either directly or indirectly, as a result of human activity. M.Kent 523. A deflected succession is a succession which has been arrested from reaching the climatic climax due to human activities.



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THE ROLE OF PRIMARY AND SECONDARY SUCCESSION IN PRESERVING BIODIVERSITY

- **Biodiversity** is the variety of life (variety of species) found in a particular habitat or ecosystem.

Role of primary succession

- Soil Formation: Pioneer species (lichens, mosses) break down bare rock, creating the first organic soil, which allows for the future colonization of diverse plant life.
- Creating New Habitats: By changing barren landscapes into hospitable environments, primary succession creates new niches for plants and animals to colonize.

- Nutrient Cycling. Through establishment of plants which absorb nutrients and also die to return them into the soil. This is enhanced by the nitrogen fixing bacteria found in legumes.
- The vegetation during primary succession also helps in preventing soil erosion. Plant roots stabilize the soil, minimizing the risk of soil erosion from wind and water.
- The established vegetation in the climax community stores carbon over the long term. This process contributes to mitigating climate change

Role of secondary succession.

- Rapid Ecosystem Recovery: Because soil and seed banks are present, secondary succession recovers biodiversity faster than primary, restoring habitats and food webs.

- Habitat Diversity through Mosaic Landscapes: Disturbance creates a mix of successional stages (e.g., grasslands, shrublands, and forests) across a landscape, which supports a wider variety of species than a single climax community alone.
- Nutrient Cycling and Soil Stabilization: Pioneer plants in secondary succession (grasses, herbs) rapidly stabilize soil, reducing erosion and restoring soil fertility after disturbances.

TECHNIQUES FOR RESTORING DEGRADED ECOSYSTEMS.

- Reforestation and Afforestation: Planting trees and native vegetation to restore forest ecosystems, prevent erosion, and capture carbon.
- Bioremediation and Phytoremediation: Using microorganisms or plants to clean up (detoxify) contaminated soil and water. Some plants and lichens adapted to soils containing heavy metals can be used to absorb the heavy metals from the soil.
- Biological augmentation: This uses organisms to add essential materials to a degraded ecosystem. e.g. nitrogen fixing plants to restore nitrates.
- Wetland and Water Restoration: Re-establishing natural hydrological processes, such as removing dams, restoring floodplains, and planting rain gardens to improve water infiltration.

- Natural Regeneration: Allowing ecosystems to heal naturally by removing pressures (e.g., stopping livestock grazing, reducing fertilizer use), allowing native seeds to sprout.
- Invasive Species Removal: Eradicating non-native species that threaten local biodiversity to allow native flora and fauna to re-establish.
- Soil Rehabilitation: Improving soil health through organic fertilization, reduced tillage, and erosion control methods like contour plowing.
- Agroecology and Sustainable Land Management: Implementing practices like crop rotation and agroforestry to make agricultural land more resilient and biodiverse.

- Active Restoration Techniques: Direct human efforts such as seed ball dispersal to jumpstart succession, constructing artificial reefs, and restoring degraded coral reefs.



BENEFITS FOR RESTORING DEGRADED ECOSYSTEMS.

Environmental Benefits

- **Climate Mitigation:** Healthy ecosystems like forests, peatlands, and seagrasses act as massive carbon sinks. Restoring just 15% of converted lands could contribute to over one-third of the total climate change mitigation required by 2030.
- **Biodiversity Recovery:** Restoration provides food, shelter, and migration routes for wildlife. Effective action can avoid up to 60% of expected species extinctions.
- **Disaster Resilience:** Intact habitats act as natural buffers. For example, restored mangroves and wetlands absorb wave energy and excess rainfall, significantly reducing the risk of coastal erosion, floods, and landslides.

- Water & Soil Health: Restored vegetation stabilizes soil to prevent erosion and filters pollutants from water sources, improving groundwater levels and overall water security.



Economic Benefits

- Job Creation: Restoration projects create millions of jobs in areas like conservation management, ecological research, and eco-friendly construction. It is estimated that over 20 million new jobs could be created globally by 2030.
- Increased Productivity: Restoring degraded farmland through sustainable practices like agroforestry can enhance soil fertility, leading to tripled harvests in some regions and improved food security for over 1.3 billion people.
- Eco-Tourism: Healthy, biodiverse landscapes attract visitors, supporting local economies through hiking, bird watching, and diving. In Costa Rica, aggressive reforestation has made tourism a multi-billion dollar contributor to the economy.



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Social, ethical and Health Benefits

- **Disease Prevention:** Degraded ecosystems increase the risk of "spillover" diseases from animals to humans. Restoration reduces human-wildlife conflict and helps regulate diseases such as ebola from monkey intruders as a result of destroying their habitats.
- **Mental & Physical Well-being:** Access to restored green spaces in urban areas reduces stress, improves air quality, and encourages physical activity, lowering rates of respiratory and cardiovascular diseases.
- **Cultural Preservation:** Many local and Indigenous communities have deep spiritual and cultural ties to their land; restoration strengthens these connections and supports sustainable, traditional livelihoods.

- Ethical fulfillment. Fulfilling the desire that all living species have a right to coexist with us on Earth.



ENERGY FLOW IN THE ECOSYSTEM.

- The study of energy flow through ecosystems is called ecological energetics.

Process of energy flow in the ecosystem

- The Sun is the ultimate source of energy in ecosystems. The light energy is converted into chemical energy by autotrophs which are the primary producers during photosynthesis. The total rate at which plants and other autotrophs synthesise organic material (such as carbohydrate) is called **gross primary production (NPP)**.

- However, some energy is lost in form of heat as result of respiration and therefore the rate at which autotrophs store organic material as new tissue after allowing for losses due to respiration is called **net primary production (NPP)**. (Net primary production = gross primary production — respiration).
- Primary consumers, the herbivores then feed of the autotrophs to obtain the energy. Once in their bodies it becomes gross secondary production (GSP).
- some energy is lost from the herbivores bodies in form of heat due to respiration. Energy stores in primary consumers which will be available for the secondary consumers is called Net secondary production. (Net secondary production = gross secondary production — respiration)

- GSP is less than NGP because some parts of the producers are indigestible since they are tough (cellulose) hence less nutrients are absorbed. And some plants die and decay before they are eaten by the consumers.
- The secondary consumers then feed on the primary consumers. And the energy they store in their bodies is also called gross secondary production. These are also fed on by tertiary consumers and so on.
- On the death of the producers and consumers, some energy locked up in the complex organic compounds is utilized by decomposers and detritivores which help to recycle these nutrients in the ecosystem.

FOOD CHAIN (BS 302)

- Is a series (chain) of organisms, each feeding on the preceding organism showing how energy is transferred from producers to consumers in an ecosystem.
- E.g
plant (such as leaves) → slug → frog → grass snake → stoat
rosebush sap → aphid → ladybird → spider → insectivorous bird → hawk
- Each stage of the food chain (each feeding level in the chain) is known as a trophic level (*trophos*, food).
- The first trophic level is occupied by the autotrophic organisms, called **producers**.

- The organisms of the second trophic level are usually called primary consumers while those of the third level are called secondary consumers, those of the fourth quaternary consumers.
- Detritivores may be fed upon by carnivores which may then be consumed by other carnivores, thus building up a food chain based on detritus. These are termed **detrital food chains** to distinguish them from the **grazing food chains. (BS 303)**



- NB: **Detritivores** (Detrital feeders) feed on small fragments of decomposing or dead material termed **detritus**.

Leaf litter → earthworms → Black bird → Sparrow hawk

- NB: The arrows show the direction of flow of energy, with the arrow head always pointing away from the organism being eaten.
- NB: There are usually four or five trophic levels, and seldom more than six. This is partly because at every trophic level some energy is wasted i.e
 - a) Much energy is lost as heat during the respiratory processes of each organism in the chain.
 - b) Some tissues are not eaten by primary consumers or remain indigested. energy remains locked up in the complex organic compounds.
 - c) Some is lost through excretion

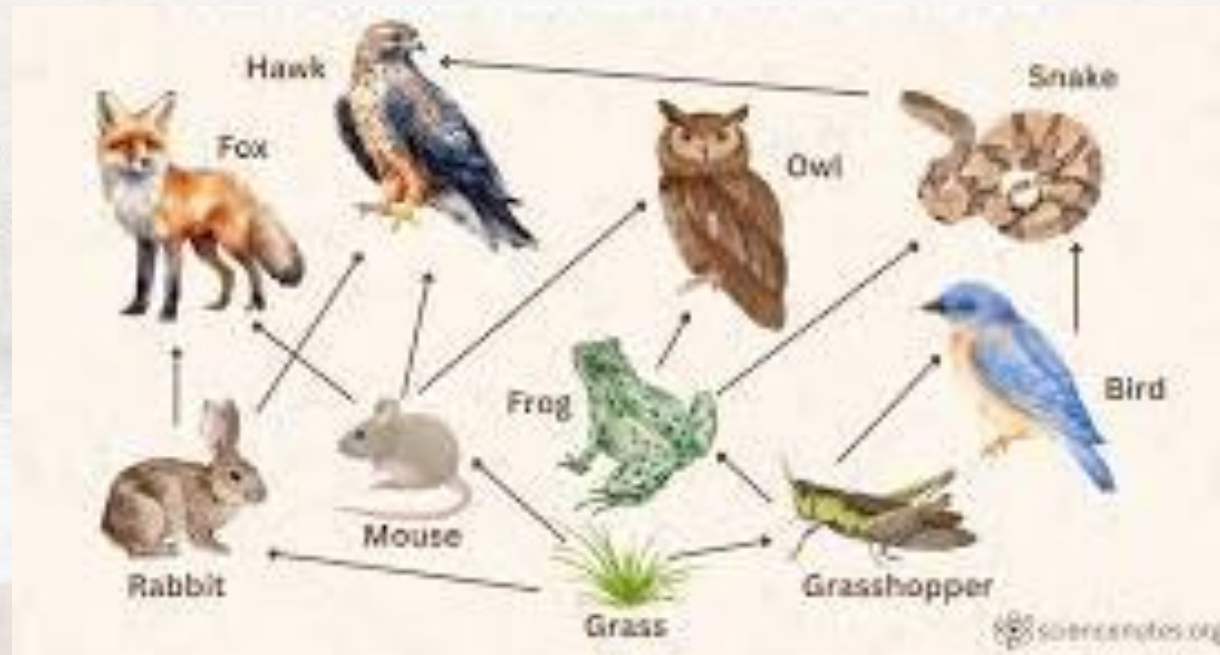
- **NB:** Energy lost in respiration cannot be transferred to other living organisms. However, the energy lost from a food chain in the form of excreta and egesta is not lost to the ecosystem because it is transferred to detritivores and decomposers. BS 309
- NB; The percentage of the energy at one trophic level which end up in the next trophic level is called the **trophic efficiency**.
- Trophic efficiency of primary consumers = $\frac{GSP}{NPP} \times 100\%$

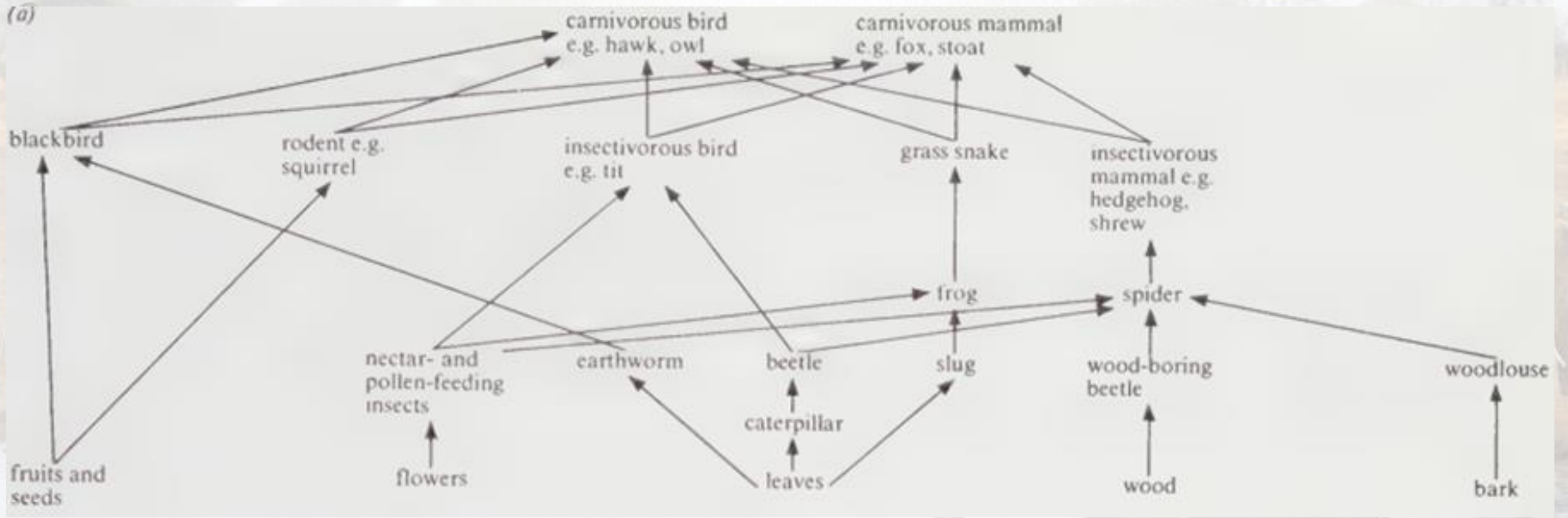
Qstn

- Explain why energy transfer from herbivores to carnivores is more efficient than that from producer to herbivore? Bs 309

FOOD WEB

- This is a complex feeding relationship showing a mesh of interlinking food chains due to the fact that most organisms in fact have a wide range of food items, and belong to more than one trophic level. (bs 304, m.kent 508)





ROLE OF ENERGY FLOW IN MAINTAINING ECOSYSTEM STABILITY

- Energy flow ensures that all trophic levels have the necessary resources for survival. Energy flows from producers (plants) to consumers and decomposers, maintaining the structural integrity of the ecosystem.
- It drives Nutrient Cycling: While energy flows through once, its passage drives the metabolic processes of decomposers that recycle nutrients, supporting the abiotic components necessary for producer growth

- It maintains a sustainable balance between the food and the consumers by Regulating Population sizes. Due to the inefficiency of energy transfer i.e loss of energy in form of heat at each trophic level, the number of organisms at trophic level is limited. This inefficiency ensures a stable, sustainable balance, as top predators cannot out number their food sources.
- It ensures resilience to Disturbances: Ecosystems with diverse food webs (multiple energy pathways) are more stable because they can adapt if one species or pathway is lost, such as through disease or environmental change

THE IMPACT OF HUMAN ACTIVITIES ON ENERGY FLOW

- Diversion of Primary Productivity: Humans divert roughly 20-30% of Earth's terrestrial net primary production for human consumption (crops, livestock, timber), leaving less energy for natural food webs.
- Destruction of vegetation to obtain land for industrialization, and urbanisation removes primary producers, creating gaps in the energy flow, which reduces food availability for herbivores and subsequent trophic levels.
- Pesticide use simplify food webs, reducing the efficiency of energy transfer and reducing ecosystem biodiversity.

- Pollution and Climate Change: Pollution (e.g., oil spills, industrial waste) and increased greenhouse gases (fossil fuel combustion) disrupt ecosystems, altering species metabolic rates, reproduction, and survival, which fundamentally changes energy pathways.
- Pollution like smoke and water pollution e.g. eutrophication , block sunlight from being absorbed by autotrophs which are the primary producers hence reducing on the primary productivity required to support higher trophic levels.

CARBON FOOTPRINT AND CLIMATE CHANGE

- **Carbon footprint** is the total amount of greenhouse gases especially carbon dioxide and methane released into the atmosphere by human actions,
- Greenhouse gases (GHGs) are gases in Earth's atmosphere that trap heat, contributing to the greenhouse effect and climate change. These gases include carbon dioxide, carbon monoxide, methane, water vapour, CFCs (Chloro Fluoro Carbons)



- The fundamental formula for calculating a carbon footprint is
Carbon footprint = Activity data x Emission factor.
- **Activity Data:** Quantifiable measures of an activity, such as kilowatt-hours (kWh) of electricity used, liters of fuel consumed, or miles traveled in a vehicle.
- **Emission Factor:** A conversion coefficient that represents the average emissions produced per unit of activity. For example, burning one gallon of gasoline has an emission factor of 8.78 kg of CO₂.
- It is expressed in tonnes of carbon dioxide equivalent (CO₂e).

- It is called carbon dioxide equivalent because it is a conversion of the warming impact of various greenhouse gases (such as methane or nitrous oxide) into the equivalent amount of carbon dioxide that would cause the same amount of warming.

Example:

- If a car consumes 2,000 km at 10 km/liter (200 liters of diesel). Using a multiplier of 2.67 kg of CO₂e per liter, 200 liters of diesel produces 534 kg of CO₂e
- If a household consumes 10,000 kWh of electricity and the grid factor is 0.193 kg CO₂e/kWh, the carbon footprint is $10,000 \times 0.193 = 1,930$ kg CO₂e.

Use of measuring the carbon footprint

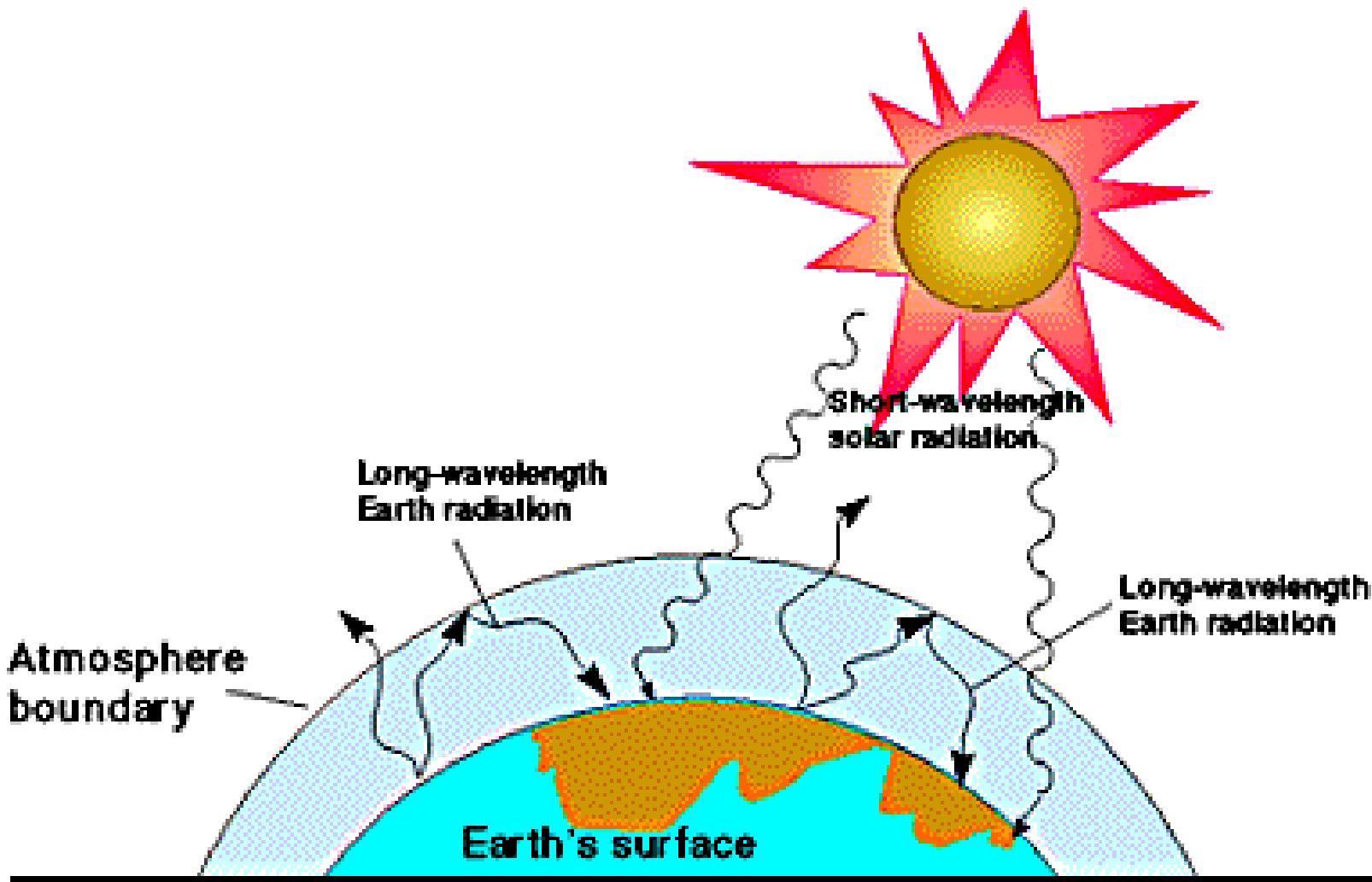
- By measuring the carbon footprint it enables enable targeted reduction strategies, and combat climate change.

NB: Very large amounts of green house gases in the atmosphere can lead to climate change especially global warming.

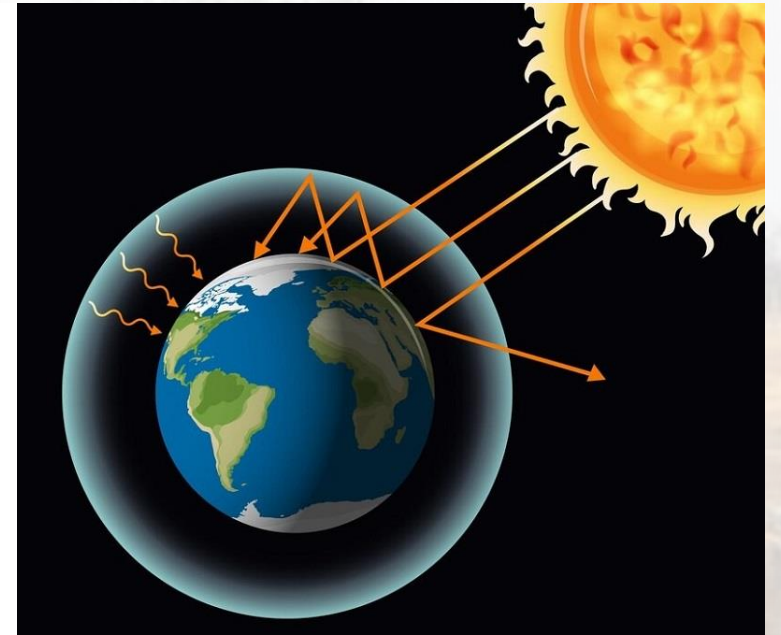


THE GREEN HOUSE EFFECT BS 326, MK 548

- Greenhouse gases i.e carbon dioxide, chlorofluorocarbons, methane, and water vapour present in the lower atmosphere, are transparent to incoming short-wave radiation from the Sun,
- This reaches the Earth and when that radiation strikes the surface, much of its energy is converted into heat, a form of radiation which has a long wavelength.
- The green house gases present in the atmosphere absorb and retain long-wave radiation and then reflect it back toward the surface of the Earth. Leading to warming of the earth.



The greenhouse effect



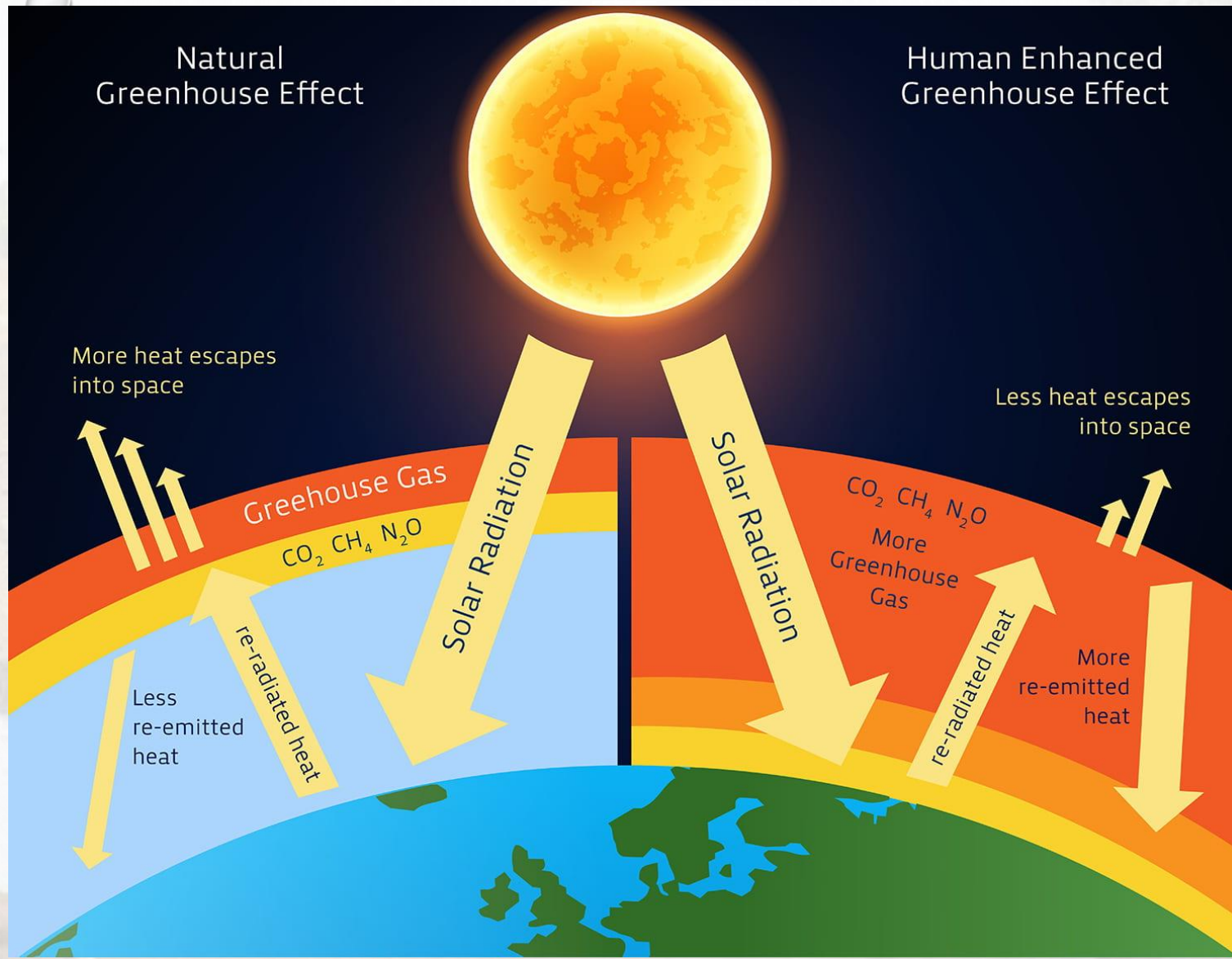
- **NB;** These gases therefore act like panes of glass in a greenhouse, letting light in, but retaining some of the heat before it escapes into space; hence the term 'greenhouse effect'
- **NB;** The retention of heat by the greenhouse effect is a natural process, essential for the evolution of life on Earth. It has been calculated that without it, average surface temperatures would be between -17 and $\sim 23^{\circ}\text{C}$; the actual average surface temperature is $+15^{\circ}\text{C}$.
- **NB;** Increased accumulation of green house gases especially carbon dioxide may lead to an increasingly warmer surface environment, namely an enhanced greenhouse effect (Global warming).

CARBON FOOT PRINT AND CLIMATE CHANGE.

- Increase in the concentration of greenhouse gases in the atmosphere is causes changes in climate by causing a rise in global temperatures i.e enhanced green house effect (Global warming)

Effects of rise in global temperatures.

- Rising sea levels due increase in the melting of ice, this leads to floods which displace a number of organisms.
- Increased evaporation hence heavy rains.
- May lead to extinction of species of organisms which cannot adapt to high temperatures.
- High temperatures and rains increase primary productivity.



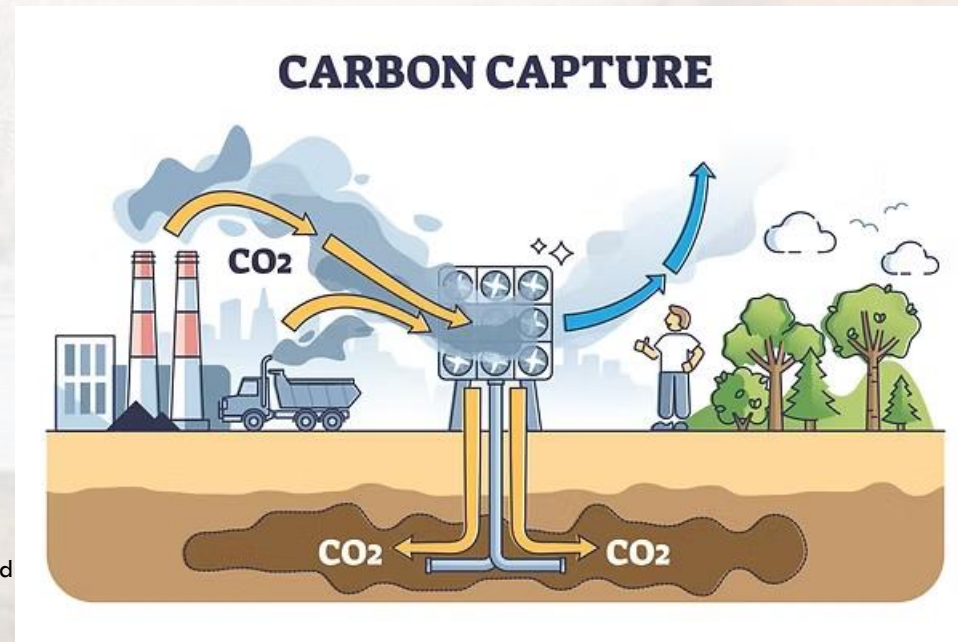
ROLE OF CARBON SEQUESTRATION IN MITIGATING CLIMATE CHANGE.

- Carbon sequestration is the natural or engineered process of capturing and storing atmospheric carbon dioxide to reduce global warming, acting as a "sink" to remove greenhouse gases. It involves two main types: biological (plants, soil, oceans) and technological (direct air capture, geological storage).



Carbon sequestration practices include.

- Afforestation
- Swamp reclamation. Vegetation capture carbon dioxide during photosynthesis and this is stored in plant bio mass.
- Direct capturing of carbon dioxide from air or industrial sources into underground rock formations.



INVASIVE SPECIES

- Invasive species are non-native organisms (plants, animals, fungi, or bacteria) introduced to a new environment usually by human activity that cause, or are likely to cause, significant harm to the environment, economy, or human health. They spread rapidly, outcompete native species, and lack natural predators, making them a top threat to global biodiversity



THE IMPACT OF INVASIVE SPECIES ON NATIVE BIODIVERSITY, ECOSYSTEMS, AND ECONOMIES

- Ecological and biodiversity impacts.
- Increased competition. Invasive species outcompete native species for resources (food, space, sunlight) especially due to absence of their natural predators in the new region.
- Increased predation. i.,e the new species may become new predators to the native species.
- Alteration of abiotic components. For example invasive species can be nitrogen fixing hence altering nutrient composition of the soil.

- Reduced biodiversity. Loss of one species due to being out competed, predation can lead to loss of other dependent species e.g loss of insects can lead to loss of their pollination dependents.
- Introduction of diseases into the ecosystem especially from pathogenic invasive species



- **Economical impacts**

- Production Losses. Loss of crops due to invasive insect pests and pathogens.
- Management and control costs due to expenditures in reducing the infestation of harmful invasive species micro organisms.
- Infrastructure Damage: algae clog water intake pipes, while others e.g fungi damage marine structures and power plants.
- Health and Social Costs: Some invasive can facilitate the spread of diseases like malaria. Invasive plants like Parthenium cause severe respiratory and skin allergies in humans.



STRATEGIES OF MANAGEMENT AND CONTROL OF INVASIVE SPECIES.

- Mechanical removal e.g hand picking or hand uprooting and hunting them down.
- Use of pesticides and herbicides to kill the harmful plant or animal invaders.
- Use of biological control by introducing their predators or pathogens to infect them with disease and kill them.
- Ensuring cleanliness of transportation vessels to prevent spread of seeds and pathogens from one place to another.

FOOD SECURITY

- Food security refers to when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life.



Tr. Naturinda Eliya

Jesus is Lord



COMPONENTS OF FOOD SECURITY

Food security consists of four core components i.e

- Food availability
- Food access
- Food utilization
- Food stability.

1. Food Availability

This refers to the physical presence of food in a specific area or region. It is determined by the "supply side" and includes:

- Production: The amount of food grown locally through agriculture, livestock, and fisheries.
- Stock Levels: Food held in government reserves, by traders, or at the household level.
- Net Trade: Food brought into an area through imports or international trade.
- Food Aid: Supplies provided by governments or NGOs in times of crisis

2. Food Access

Even if food is available, individuals must have the physical and economic means to obtain it. Key factors include:

- **Affordability:** Having sufficient income, purchasing power, or financial resources to buy food at market prices.
- **Physical Infrastructure:** The ability to reach markets safely and within a reasonable timeframe via roads and transport links.
- **Social Access:** The removal of barriers related to gender, ethnicity, or legal arrangements that might prevent certain groups from getting food

3. Food Utilization

Utilization focuses on how the body absorbs and uses nutrients from the food consumed. It depends on:

- Dietary Diversity: Consuming a variety of safe, nutritious foods to meet all physiological needs.
- Food Safety: Ensuring food is prepared in hygienic conditions with access to clean water and proper sanitation.
- Health Status: The body's ability to metabolize nutrients, which can be hindered by illnesses or lack of healthcare

4. Food Stability

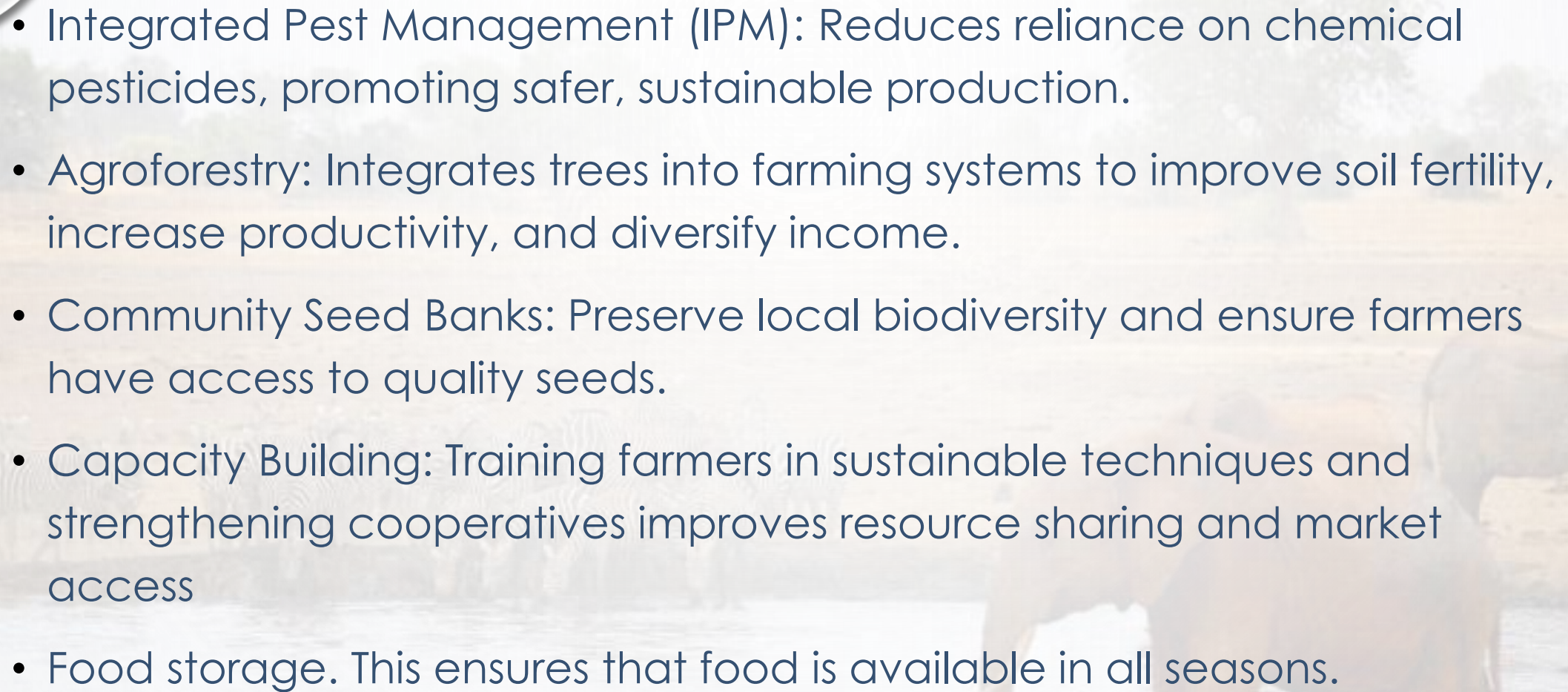
This introduces the dimension of time, ensuring that availability, access, and utilization are consistent and reliable.

- Shock Resistance: The ability of the food system to withstand sudden events like natural disasters, economic crises, or conflict.
- Seasonal Consistency: Ensuring food remains accessible during "lean seasons" before harvests when prices typically rise

NB: **Food Insecurity** occurs when these conditions are not met, leading to hunger or malnutrition

AGRICULTURAL PRACTICES TO ADDRESS CHALLENGES OF FOOD INSECURITY.

- Growing drought-Tolerant Crops: Utilizing improved seed varieties to ensure yields during adverse weather.
- Irrigation farming: Implementing efficient systems like drip irrigation to mitigate water scarcity.
- Minimum tillage: Minimizes soil erosion and preserves soil structure.
- Cover Cropping & Mulching: Protects soil quality and enhances water retention.
- Crop Rotation and Intercropping: Improves soil fertility and reduces pest risks

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- Integrated Pest Management (IPM): Reduces reliance on chemical pesticides, promoting safer, sustainable production.
 - Agroforestry: Integrates trees into farming systems to improve soil fertility, increase productivity, and diversify income.
 - Community Seed Banks: Preserve local biodiversity and ensure farmers have access to quality seeds.
 - Capacity Building: Training farmers in sustainable techniques and strengthening cooperatives improves resource sharing and market access
 - Food storage. This ensures that food is available in all seasons.



END

Making biology easy

BY Tr. Eliya