Lecture 5. Producers, consumers and decomposers of an ecosystem. Energy flow in the ecosystem. Types of ecosystems.

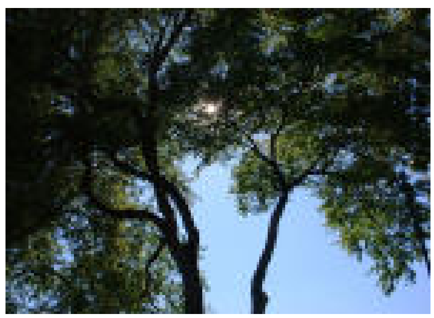
Our environment consisting of both living and non-living systems, influence each other in form, function and property which is necessary to maintain life. The composition of the living and the non-living systems are the building blocks of an ecosystem.

Producers

In an ecosystem, producers are those organisms that use photosynthesis to capture energy by using sunlight, water and carbon dioxide to create carbohydrates, and then use that energy to create more complex molecules like proteins, lipids and starches that are crucial to life processes. Producers, which are mostly green plants, are also called autotrophs.

Producers funnel into the ecosystem the energy needed for its biological processes. The carbohydrates and other organic chemicals formed by the producers are utilized by the heterotrophs, or consumers; first by the herbivores who eat the plants--the primary consumers--then by the predators who eat the herbivores--the secondary, tertiary, and so on consumers. But at each step, much energy is lost. Less than 10 percent of the energy stored in plants is converted to herbivore mass. The loss from herbivore to predator is similar. Thus energy needs to be added to the ecosystem continuously.

Producers : Organism which produces its own food by using energy from the sun



Consumers

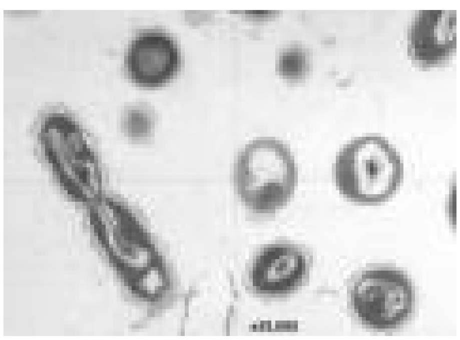
Consumers are organisms (including humans) that get their energy from producers, regarding the flow of energy through an ecosystem. For example, producers, (such as plants), make their own food by the process of photosynthesis. An organism ate this plant, than it would be a primary consumer. The animal that eats *this* animal is known as the second order consumer. Scientifically, all consumers are either herbivores, carnivores, omnivores or detrivores (decomposers and other organism that break down organic matter). These 'orders' are known as trophic levels.

Consumers : Organism which doesn’t make its own food, but gets it from eating plants or other animals

Decomposers

Decomposers eventually convert all organic matter into carbon dioxide (which they respire) and nutrients. This releases raw nutrients (such as nitrogen, phosphorus, and magnesium) in a a form usable to plants and algae, which incorporate the chemicals into their own cells. This process resupplies nutrients to the ecosystem, in turn allowing for greater primary production. Although decomposers are generally located on the bottom of ecosystem diagrams such as food chains, food webs, and energy pyramids, decomposers in the biosphere are crucial to the environment. By breaking down dead material, they provide the nutrients that other organisms need to survive. As decomposers feed on dead organisms, they leave behind nutrients. These nutrients become part of the soil. Therefore, more plants can grow and thrive.

Decomposer: Organism which digests or breaks down formerly living material



Ecological pyramids

The trophic structure and function at successive trophic levels, i.e. producers - herbivores - carnivores, may be shown graphically by means of ecological pyramids where the first or producer level constitutes the base of the pyramid and the successive levels, the tiers making the apex.

The graphic expression of the trophic structure and function at successive trophic level is referred as “Ecological Pyramids”. Ecological Pyramids are of three types;

i) Pyramid of numbers refers to number of individual organisms at each level.
ii) Pyramid of biomass refers to total dry weight of total amount of living matter
iii) Pyramid of energy shows the rate of energy flow/productivity at successive energy level.

The pyramids of numbers and biomass may be upright or inverted depending upon the nature of the food chain in the particular ecosystem, whereas pyramids of energy are always upright.

Tertiary consumers (carnivores)

↑

Secondary consumers

↑

Primary consumers (herbivores)

↑

Producers

Pyramid of numbers

It shows the relationship between producers, herbivores and carnivores at successive trophic level in terms of their numbers. In grassland ecosystem, producers are maximum in number. This number then shows a decrease towards apex as the primary consumer/herbivore are lesser in number than producers and tertiary consumers are least in number. So pyramid becomes upright. But in forest ecosystem, producers are lesser in number, which forms the base of pyramid. Herbivores - fruit/eating birds, elephants, deers etc. are more in number than producers.

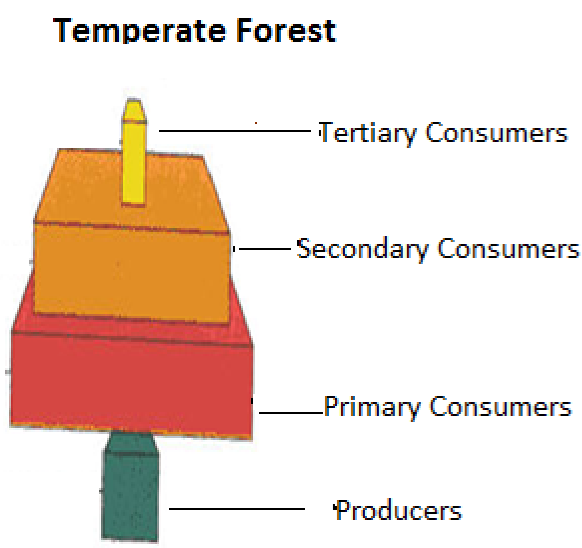
In parasitic food chain, pyramids are always inverted. Number of organisms gradually shows an increase making the pyramid inverted.

Pyramids of Biomass

In grassland and forest ecosystems, the pyramid of biomass shows an upright position. But in ponds and other aquatic systems, producers are small organisms and biomass is also least. This value shows an increase towards the apex of the pyramid and making the pyramid inverted.

Pyramids of Energy

Of the three types of ecological pyramid, this energy of pyramid gives the best picture of overall nature of the system. It is a picture of the rates of passage of food mass through food chains. So it’s shape is always upright. Because there is always a gradual decrease in the energy content at successive trophic levels from the producers to various consumer.



Energy flow models

The behaviour of energy in an ecosystem can be termed, as energy flow. It is always unidirectional. From energetics point of view it is essential to understand for an ecosystem (i) the efficiency of the producers in absorption and conversion of solar energy. (ii) the use of this converted chemical form of energy by the consumers. (iii) the total input of energy in form of food and its efficiency of assimilation. (iv) the loss through respiration heat, excretion etc., and (v) the gross net production.

There are two models to explain the flow of energy.

1. Single channel energy models (SCEM)

2. 'Y' shaped/2 channel energy flow models

Single channel energy model

This model explains the unidirectional flow of energy. Whatever the energy captured by the autotrophs does not revert back to solar input. As it moves progressively through the various trophic levels, it is no longer available to the previous level.

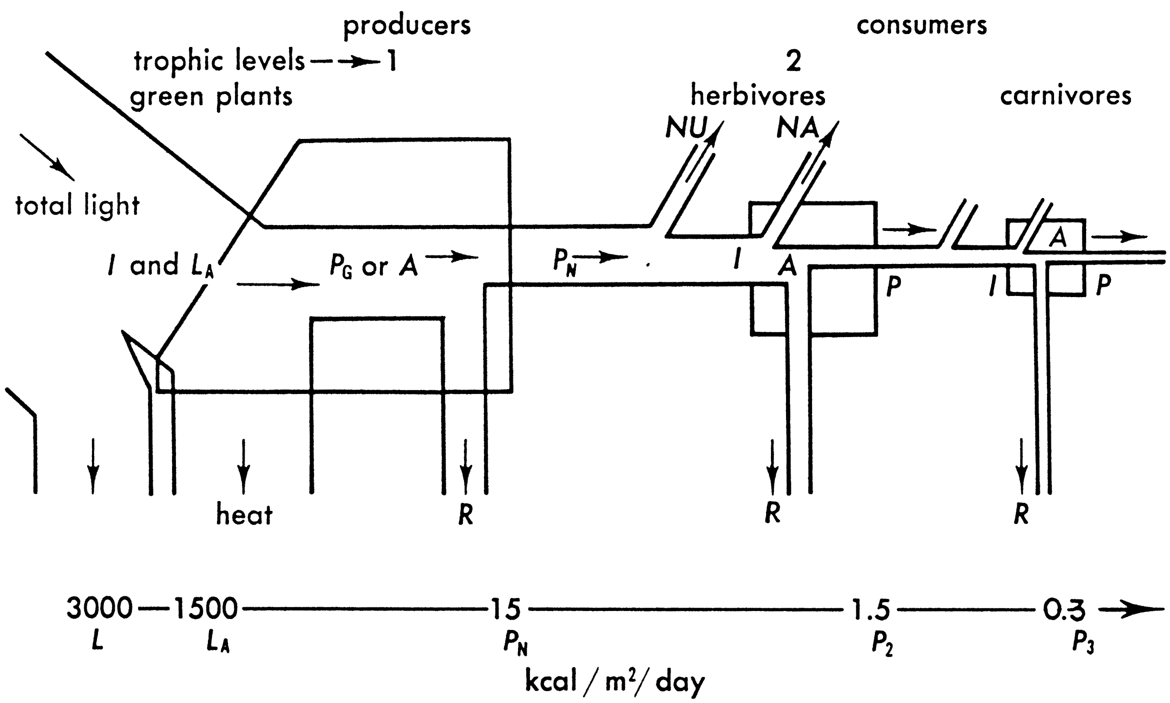
- the system would collapse if the primary source, the sun, were cut off.
- there is a progressive decrease in energy level at each trophic level.

So, shorter the food chain, greater would be the available food energy.

"Y" shaped energy flow model

It is applicable to both terrestrial and aquatic ecosystems. In this energy model, one arm represents herbivore food chain and the other arm represents the decomposer (detritus) food chain. The primary producers are entirely different for each arms. This model also indicates that two food chains are infact, under natural conditions, not completely isolated from one another.

(i) it confirms to the basic stratified structure of ecosystem.
(ii) it separates the grazing and detritus food chains in both time and space, and
(iii) micro consumers and macro consumers differ greatly in size and metabolic relations.



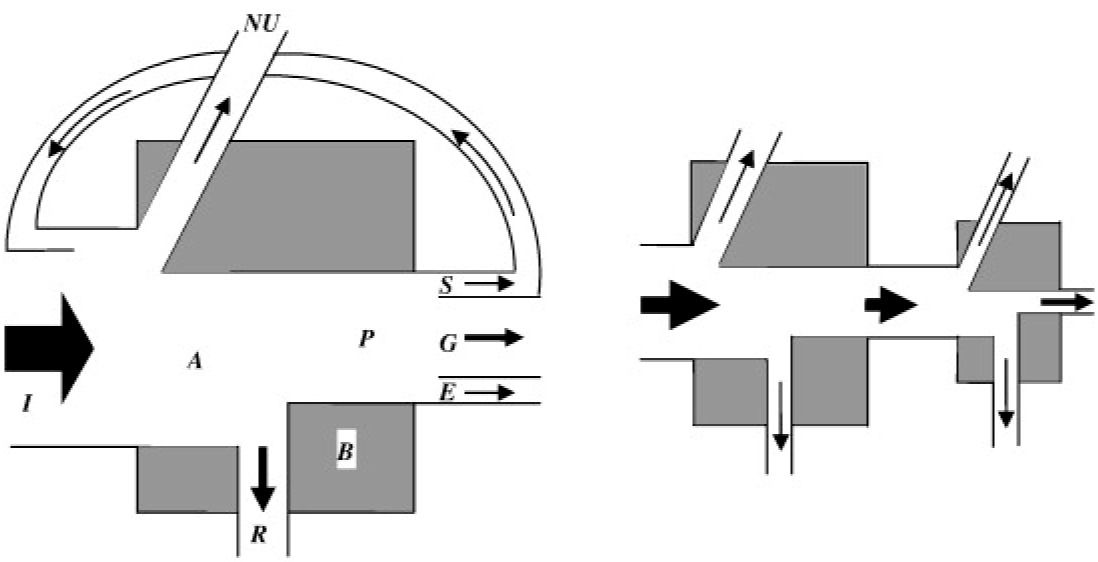
Source: Odum, E.P. (1971)

I = input or ingested energy; ***NU***= not used; ***A*** = assimilated energy; ***P***= production;
R = respiration; ***B***= biomass; ***G***= growth; ***S***= stored energy; ***E***= excreted energy.

Universal model of energy flow

Proposed by Odum. It is applicable to any living component whether a plant, animal /microorganisms or individual/population or a trophic group. It may depict food chain as shown in single/Y shaped energy flow system or bioenergetics of entire system.

These models depict the basic pattern of energy flow in ecosystem. Under natural conditions, these organisms are inter related in a way that several food chains become interlocked this results into a complex food web. Complexity of food web depends on the length of the food chain. Thus in nature, there operate multi channel energy flows. But in these the channels belong to either of the two basic food chains - Grazing or Detritus. Interlocking pattern of such several chains in food web of an ecosystem would lead to a multi channel flow of energy. Thus in practice, under food conditions, it is difficult to measure the energetics of the ecosystem.



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Food Chain

A **food chain** shows how each living thing gets its food. Some animals eat plants and some animals eat other animals. For example, a simple food chain links the trees & shrubs, the giraffes (that eat trees & shrubs), and the lions (that eat the giraffes). Each link in this chain is food for the next link. A food chain always starts with plant life and ends with an animal.

1. Plants are called **producers** because they are able to use light energy from the Sun to produce food (sugar) from carbon dioxide and water.

2. Animals cannot make their own food so they must eat plants and/or other animals. They are called **consumers**. There are three groups of consumers.

    a. Animals that eat ONLY PLANTS are called **herbivores** (or primary consumers).

    b. Animals that eat OTHER ANIMALS are called **carnivores**.

        - carnivores that eat herbivores are called secondary consumers

        - carnivores that eat other carnivores are called tertiary consumers
          e.g., killer whales in an ocean food web ... phytoplankton → small fishes → seals → killer whales

3. Animals and people who eat BOTH animals and plants are called **omnivores**.

4. Then there are decomposers (bacteria and fungi) which feed on decaying matter. These decomposers speed up the decaying process that releases mineral salts back into the food chain for absorption by plants as nutrients.

The consumer organisms are heterotrophic. Unlike the autotrophic plants, which manufacture their own food from simple inorganic chemicals, the herbivores must utilize the energy-rich compounds synthesized by the plants. In turn, the carnivores obtain energy for their metabolism when they consume the herbivores.

Phytoplanktons ⟶ Zoos planktons ⟶ Fish

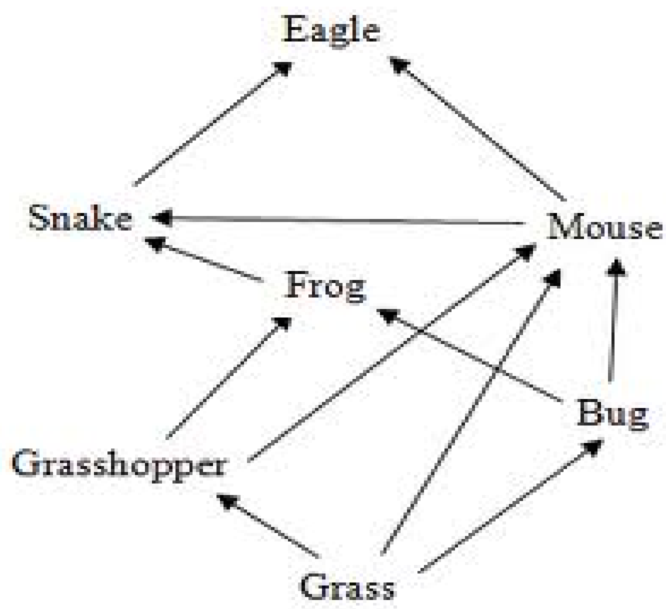
Grasses ⟶ Rabbit ⟶ fox

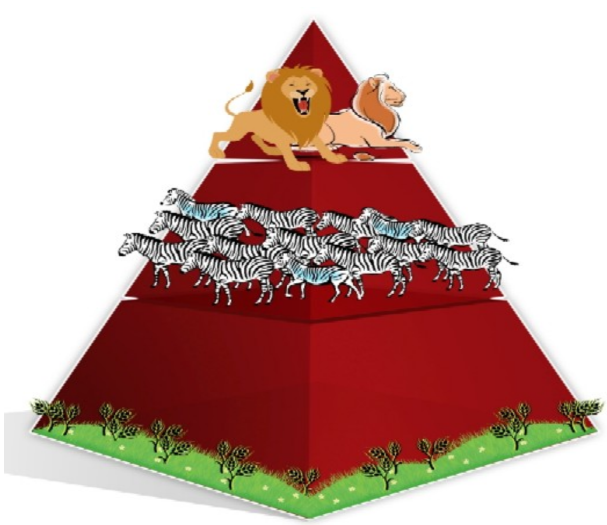
Grasses ⟶ grasshopper ⟶ Frog ⟶ Snake ⟶ Hawk

Small Bacteria ⟶ Bdellovibio ⟶ Protozoa

Food Web

There cannot be too many links in a single food chain because the animals at the end of the chain would not get enough food (and hence energy) to stay alive. Most animals are part of more than one food chain and eat more than one kind of food in order to meet their food and energy requirements. These interconnected food chains form a **food web** ie. Interlocking pattern of food chain is called food web.





This interdependence of the populations within a food chain helps to maintain the balance of plant and animal populations within a community. For example, when there are too many zebras; there will be insufficient shrubs and grass for all of them to eat. Many zebras will starve and die. Fewer zebras means more time for the shrubs and grass to grow to maturity and multiply. Fewer zebras also mean less food is available for the lions to eat and some lions will starve to death. When there are fewer lions, the zebra population will increase.

Ecosystems

The first steps in the evolution of agriculture were the tending of particular plant species and the taming of useful animal species. The next steps were (a) domestication of these species so as to gain control of their reproduction thereby enabling selective breeding of more productive types and (b) creation of special environmental conditions which would enable these improved types to realize their higher production potential. These environmental modifications involve soil tillage, soil water management, weeding and pest control. The resulting combination of humans, domesticated plant and animal species and their modified environments is an *agro-ecosystem*, in contrast to natural ecosystems in which humans play no special role. In agro-ecosystems, the farmer is an essential ecological variable, influencing or determining the composition, functioning and stability of the system.

Agro-ecosystems may be viewed as food procurement systems in which the natural ecosystem has been modified to various degrees in order to increase output of food and other useful products of value to humans. The dominants in agro-ecosystems are selected plant and animal species which are tended and harvested by humans for particular purposes. According to the nature of the modifications, agro-ecosystems range from shifting agriculture, nomadic pastoralism, and non-industrial continuous agriculture to ranching, industrial agriculture and feedlot animal production. The first three systems are practiced primarily for subsistence, and may therefore be called **subsistence agro-ecosystems**, while the last three are **industrial agro-ecosystems** which are geared to a market economy. Agro-ecosystems which involved field crop husbandry *viz*., shifting agriculture, non-industrial continuous agriculture and industrial agriculture are also referred to as field crop ecosystems.

Intensive and extensive agro ecosystems

Agro-ecosystems are classifiable according to whether they are extensive or intensive. Extensive systems may be defined as those where the annual output of consumable nitrogen is less than 20 kg per ha. Outputs of crop or livestock products per unit area are low, and these outputs are dependent largely on natural soil nutrient reserves and management which conserves these reserves. Forms of subsistence agriculture such as nomadic pastoralism and shifting agriculture are widespread examples.

In intensive agro-ecosystems, very high outputs are maintained by large inputs of nutrients. Both the volume and rate of nutrient cycling are much higher than in extensive systems, particularly in industrial agriculture. Since nutrient inputs are almost entirely in the form of inorganic fertilizers, nitrogen fixation and soil organic matter are both depressed to very low levels. Losses of nutrients from the system through exports of produce are great, while considerable leaching losses, of both soil nutrient reserves and nutrient inputs occur particularly in wetter environments when land is bare during part of the growing season.

Agro-ecosystems which involve a significant livestock sub-system as well as a cropping sub-system are known as *mixed farming* systems. They are usually intermediate in intensity between extensive and intensive agro-ecosystems.

Shifting agriculture

Shifting agriculture is a very widespread agro-ecosystem in the tropics. It includes a wide range of different localized systems which have developed in response to local environmental and cultural conditions. The essential features of the agro-ecosystem are that fields are rotated rather than crops, and a fallow period restores soil fertility. Disturbance to the soil is also negligible since there is no soil tillage. The system is well suited to nutrient poor soils in areas of low population density. Provided the fallow period is long enough, relative to the cropping period, the agro-ecosystem is sustainable indefinitely. The cropping phase is just another human induced and managed disturbance in the natural, continuing pattern of gap creation and secondary succession in forest. The cleared area, during the period of cropping, is often referred to as a swidden.

Because of their great age and highly leached condition, most soils in the moist tropics are too poor to sustain high levels of crop production without fertilizer application. In shifting agriculture, the fertilizer requirement is provided in the form of ash by felling and burning the forest vegetation prior to cropping. When the land is abandoned after one to three years of cropping, soil regains its original fertility characteristics through forest regeneration, provided the fallow period is of sufficient duration.

Nomadic Pastoralism

Nomadic pastoralism is a subsistence agro-ecosystem which usually prevails in semi-arid or arid regions which are too dry to sustain rain fed, field crop ecosystems. Human densities associated with nomadic pastoralism are low, much lower than in shifting agriculture. This is largely due to two reasons *viz*., (a) low and unpredictable primary production caused by low and highly erratic rainfall and (b) dependence on secondary production by warm blooded herbivores. This result is only a small proportion of the energy fixed in primary production being available to humans, who are secondary consumers in this agro-ecosystem. Pastoralism however allows conversion of low quality, inedible plant biomass *viz*., grass, to high quality foods *viz*., meat and milk, in regions which would not support any people on the basis of crop production.

In range grazing, a high proportion of nutrients is recycled via plant residues since the proportion of available herbage consumed by livestock or other herbivores is low. The nutrient cycle is thus small in magnitude and highly dependent on release of nutrients by organic matter decomposition. The rate of this process is impeded by the lack of soil moisture over a large part of the year. The practice of burning speeds up nutrient turnover but it also increases losses of nitrogen. All nutrients are also subject to loss by runoff due to heavy rainfall intensities during the short wet season. Nitrification is also very slow. In nomadic pastoralism, manipulation of the environment is usually limited to selection of grazing routes and watering sites. The environment is manipulated to a greater extent where wells are provided to improve water supplies for cattle and where fires are set off to improve the quality and quantity of natural grazing.

Non-industrial and semi-industrial continuous agriculture

Eco-systems created by humans and characterized by continuous field crop husbandry are often termed *field crop ecosystems*. They are cultivated plant communities which are managed to achieve goals such as the production of food and other useful agricultural commodities; financial gain; and personal satisfaction. Usually, they are managed to achieve a combination of these goals. Field crop ecosystems fall into two main categories *viz*., non-industrial agriculture and industrial agriculture. Those in the former category are largely self contained agro-ecosystems, while those in the latter category are part of, and dependent upon, other elements within larger agro-ecosystems. Field crop ecosystems differ from natural ecosystems in several plant and community characteristics as well as in their functioning. These differences are summarized below

Characteristics of field crop and natural ecosystems

Characteristic	Field crop system	Natural ecosystem
Goals	Purposeful	Not purposeful
Control	Largely human	Largely biological
Plant Characteristics		
Genetic Variability	Low	High
Life History Strategy	Opportunistic	Conservational
Life Cycles	Mostly annual	Perennial/Mixed
Energy in Reproduction	Large	Small
Community Characters		
Total Biomass	Low	High
Plant architecture	Simple	Complex
Species Diversity	Low	High
Food Chains	Simple, short	Complex, long
Population Levels	Fluctuating	Fairly Constant
Response Times	Fairly fast	Slow
Energetics		
NPP : Biomass Ratio	High	Low
Standing Biomass	Low	High
Nutrient Cycles	Open, leaky	Closed, tight

Field crop ecosystems may be categorized as monocultural systems when they are dominated by a single crop species and as multi-crop systems when no single crop species is dominant. There is a continuous gradient from high input monocultural systems at one end of the spectrum to low input multi-crop system at the other. Mixed farming systems, in which cropping and livestock subsystems are integrated within a single agro-ecosystem, constitute a special category of multi-cropping systems, in which one or more of the crops grown are grazed or used as fodder. Besides outputs in various forms such as meat and milk, the livestock subsystem also provides the cropping subsystem with (a) fertilizer in the form of manure and (b) a source of power for various operations such as soil tillage, weeding and irrigation of crops, and transport and processing of crop harvests. Energy use efficiency is however lowered where the agro-ecosystem includes a livestock subsystem.

Industrial Agriculture

Industrial agriculture is primarily distinguished by the substitution of fossil fuel energy for human labour and animal power. Two persons may be employed per ha in non-industrial continuous agriculture, whereas only 0.1 person may be needed per ha in industrial agriculture. The fossil fuel energy subsidy is used to produce agro-chemicals such as fertilizers, pesticides and herbicides; to manufacture farm machinery; to operate this machinery in the performance of work such as soil tillage, planting and harvesting of crops, and application of fertilizers or pesticides and for irrigation and transport.

Because of the massive amounts of energy required to produce chemical fertilizers, pesticides and weedicides on the one hand, and to manufacture and operate agricultural machinery on the other; industrial agriculture is highly intensive in its use of energy subsidies. The increased use of energy subsidies is associated with increase in energy output per unit area and per man-hour, but the ratio of energy output to energy input decreases. Efficiency of energy use in semi-industrial and industrial agriculture is therefore considerably lower than in non-industrial agriculture with efficiency decreasing sharply as the energy subsidy increases.

In industrial agriculture, a primary objective is to maximize yields, and this is achieved largely through increasing use of chemical fertilizers. A major disadvantage of reliance on chemical fertilizers, apart from their cost to subsistence farmers, is their role in further depleting the already low organic matter content of tropical soils. Control of pests and pathogens in industrial agriculture relies heavily on the use of chemical pesticides. Pesticide use has however created almost as many problems as it was designed to solve.

Industrial agriculture displays many of the characteristics of manufacturing industry such as high capital expenditure on buildings and machinery; specialization of production; and large outputs of wastes which are not recycled within the system. Wastes from industrial agriculture, such as chemicals leached in drainage, are significant pollutants of other ecosystems. The most harmful effects of industrial agriculture on the environment are however due to soil tillage and undue exposure of bare soil, resulting in accelerated soil erosion and consequent depletion of the soil resource base.

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1.	Which of the following is not an abiotic factor that sharps ecosystem	
	a))Soil minerals	b) **Predators**
	c)) Fire	d) Rainfall
2.	The association in which food for one organism is derived by killing the host is	
	a)Parasitism,	b) **Predation,**
	c) Commensalism.	d) Symbiosis
3.	The association in which food for one organism is derived without affecting the host is	
	a) Parasitism,	b) Predation,
	c) Commensalism.	d) Symbiosis
4.	Occurrence of relatively definite sequence of communities over a period of time in the same area is known as	
	a)Ecosystem	**b) ecological succession**
	c) Ecotone	d) Biome
5.	**---------------** is the type of interaction in which both the organisms are benefited and also the interaction is obligatory for both the organisms.	
	a) Symbiosis	b) Commensalism.
	c) Parasitism,	d) Predation,
6.	Biotic environment includes	
	(a) producers	(b) consumers
	(c) decomposers	**(d) all the above**
7.	The farmer is an essential ecological variable, influencing the composition, functioning and stability of ---------------------------------	
	a)Terrestrial Ecosystem	**b) AgroEcosystem**
	c)Industrial Agriculture	d)All the above
8.	Shifting agricultuture , Nomadic Pastrolism and non industrial agriculture are practiced in	

	a)Industrial Agroecosystem	**b)Subsistence agroecosystem**
	c)Non Industrial agroecosystem	d)All the above
9.	Extensive agroecosystem is those where the annual output of consumable Nitrogen is --------------	
	a)20 kg/ha	b)40 kg/ha
	c)30 kg/ha	d)25 kg/ha
10	Transfer of energy one trophic level to another is referred is ……………… **(Food Chain)**	
11.	The process of conversion of organic form of nutrients into inorganic form is referred as **…………..** **(Mineralization)**	
12.	Pyramids of energy in all the eco system is always in ……. position.**(Upright)**	
13.	Microorganisms that utilizes organic compounds as carbon and energy sources are referred as ---------------------- **(Heterotrophs)**	
14	Final stage of community development is called as ______ **(Climax)**	
15	One of the Fundamental balances of the nature is --------------- and ------------- by which the oxygen is balanced in nature **(Photosynthesis and Respiration)**	
16	The food chain is opened by producers in grazing food chain and closed by --------------- **(Decomposers)**	
17	Since nutrient inputs are entirely in the form of inorganic fertilizers, nitrogen fixation and soil organic matter are depressed to very low levels in --------------- . **(Extensive agricultural system)**	
18	Mixed farming system is ------------------------------------- **(Livestock and cropping subsystem)**	