Ch 12 · Ecosystem

अध्याय 12 · पारितंत्र

Class 12 Biology · NCERT based · English + हिंदी · ✍️ revision notes

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4 functions of an ecosystem · पारितंत्र के 4 कार्य



Infographic: Functional aspects of an ecosystem

Introduction / परिचय

Ecosystem (पारितंत्र) = a functional unit of nature, where living organisms interact among themselves & also with the surrounding physical environment.

पारितंत्र प्रकृति की एक क्रियात्मक इकाई है जिसमें जीवधारी आपस में तथा अपने आसपास के भौतिक पर्यावरण से पारस्परिक क्रिया करते हैं।

- Size varies greatly – from a **small pond** to a **large forest or a sea**.
- Many ecologists regard the entire **biosphere as a global ecosystem** – a composite of all local ecosystems on earth.
- Since this system is too big & complex to be studied at one time, it is convenient to divide it into two basic categories:

Terrestrial (स्थलीय)	Aquatic (जलीय)	Man-made (मानव-निर्मित)
Forest, grassland, desert	Pond, lake, wetland, river, estuary	Crop fields, aquarium

📌 **Syllabus note:** In the rationalised NCERT book (2023 onwards), the sections **ecological succession, nutrient cycling & ecosystem services** were removed from this chapter. These notes follow the current book.

I. Ecosystem – Structure & Function / पारितंत्र – संरचना एवं कार्य

- Interaction of **biotic & abiotic components** results in a physical structure that is characteristic for each type of ecosystem.
- Identification & enumeration of plant & animal species of an ecosystem gives its **species composition**.
- **Vertical distribution** of different species occupying different levels = stratification (स्तरीकरण). e.g. in a forest, **trees** occupy top vertical strata or layer, **shrubs** the second, and **herbs & grasses** occupy the bottom layers.

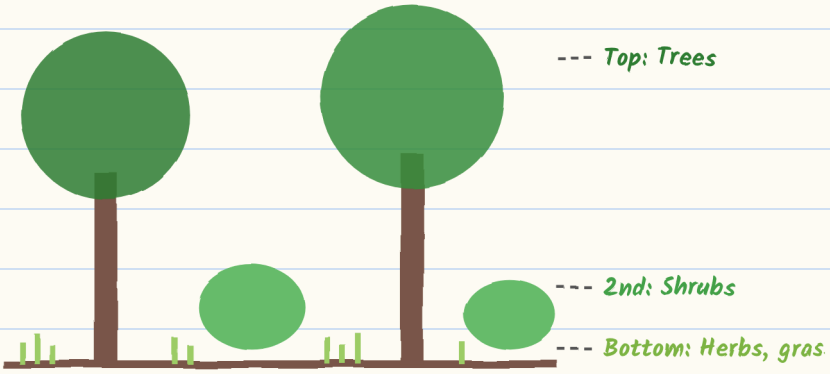
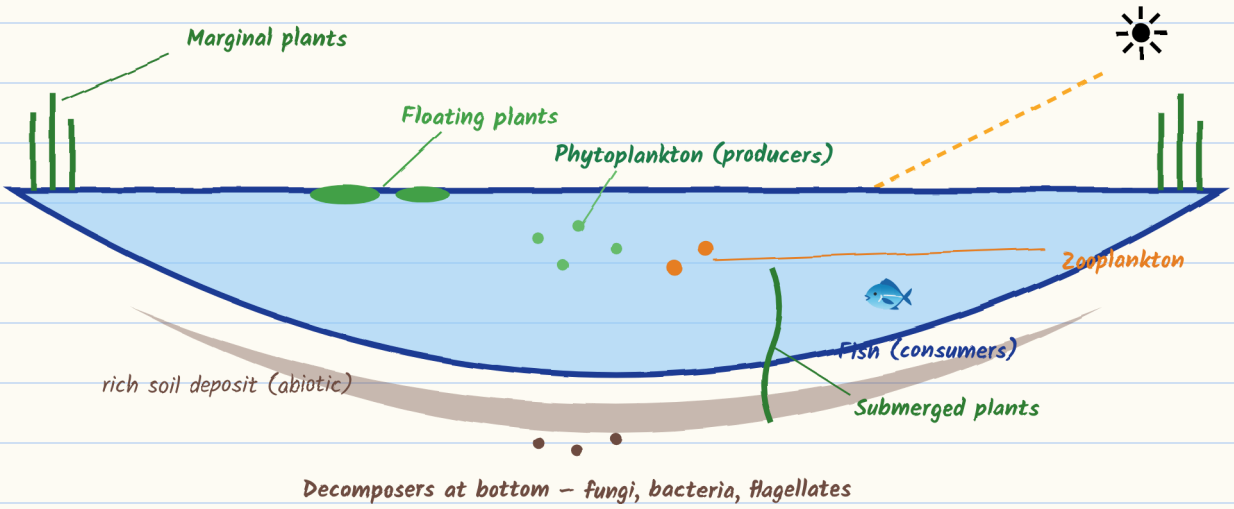


Fig: Vertical stratification in a forest · वन में स्तरीकरण

Pond – a simple ecosystem तालाब पारितंत्र



Infographic: Components of a pond ecosystem · तालाब पारितंत्र के घटक

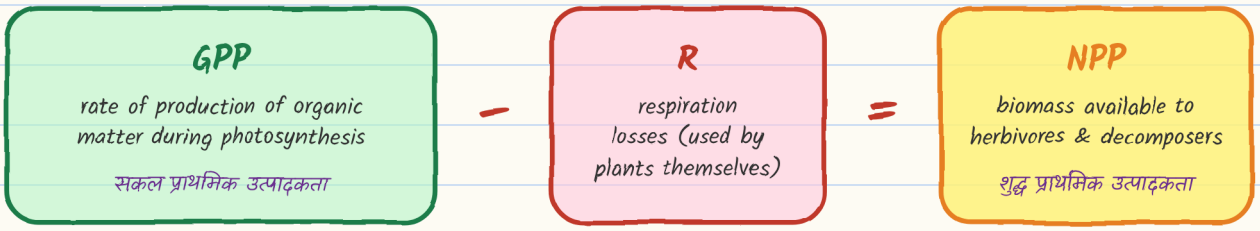
Component	In a pond
Abiotic (अजैव)	Water with dissolved inorganic & organic substances; rich soil deposit at bottom. Solar input, cycle of temperature, day-length & other climatic conditions regulate the rate of function of the entire pond
Producers (autotrophs) (उत्पादक)	**Phytoplankton**, some algae, floating, submerged & marginal plants at the edges
Consumers (उपभोक्ता)	**Zooplankton**, free-swimming & bottom-dwelling forms
Decomposers (अपघटक)	**Fungi, bacteria & flagellates** – especially abundant at the bottom of the pond

Pond performs all functions of an ecosystem:

1. Conversion of inorganic into organic material with the help of radiant energy of sun by **autotrophs**.
2. Consumption of autotrophs by **heterotrophs**.
3. **Decomposition & mineralisation** of dead organic matter to release them back for reuse by autotrophs.
4. There is unidirectional movement of energy towards higher trophic levels & its dissipation & loss as **heat** to the environment.

2. Productivity / उत्पादकता

- A constant input of **solar energy** is the basic requirement for any ecosystem to function & sustain.
- **Primary production** (प्राथमिक उत्पादन) = amount of **biomass or organic matter produced per unit area over a time period** by plants during photosynthesis. Expressed in terms of **weight (g m^{-2})** or **energy (kcal m^{-2})**.
- Rate of biomass production = productivity. Expressed in **g m^{-2} yr^{-1}** or **(kcal m^{-2}) yr^{-1}** to compare productivity of different ecosystems.
- Divided into **gross primary productivity (GPP)** & **net primary productivity (NPP)**.



Infographic: Gross vs Net Primary Productivity

- **GPP** of an ecosystem = rate of production of organic matter during **photosynthesis**.
- A considerable amount of GPP is utilised by plants in **respiration (R)**.
- Gross primary productivity minus respiration losses (R) = net primary productivity (NPP) : **GPP − R = NPP**.
- NPP is the available biomass for the consumption to **heterotrophs** (herbivores & decomposers).
- **Secondary productivity** (द्वितीयक उत्पादकता) = rate of formation of new organic matter by **consumers**.
- Primary productivity depends on the plant species inhabiting a particular area. It also depends on a variety of environmental factors, availability of nutrients & photosynthetic capacity of plants → varies in different types of ecosystems.

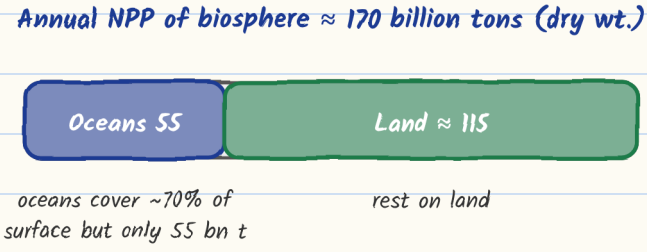
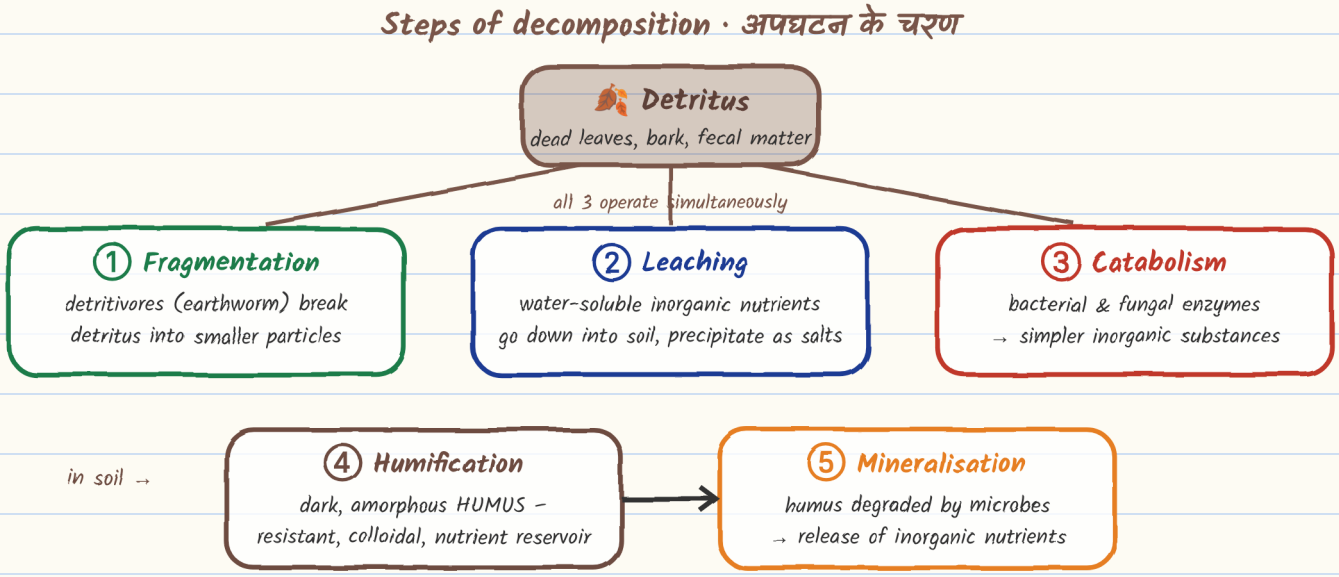


Fig: Distribution of primary productivity

📌 **Remember:** Annual NPP of the whole biosphere is approximately **170 billion tons (dry weight)** of organic matter. Of this, despite occupying about **70% of the surface**, productivity of **oceans is only 55 billion tons**. Rest is on land.

3. Decomposition / अपघटन

- **Earthworm** = 'farmer's friend' – helps in breakdown of complex organic matter & loosening of soil.
- **Decomposers** break down complex organic matter into **inorganic substances like CO_2, water & nutrients** = decomposition (अपघटन).
- **Detritus** (अपरद) = dead plant remains (leaves, bark, flowers) & dead remains of animals, including fecal matter → the **raw material** for decomposition.



Infographic: Important steps in the process of decomposition

Step	What happens
Fragmentation (खंडन)	**Detritivores** (e.g. earthworm) break down detritus into smaller particles
Leaching (निक्षालन)	Water-soluble inorganic nutrients go down into the soil horizon & get **precipitated as unavailable salts**
Catabolism (अपचय)	**Bacterial & fungal enzymes** degrade detritus into simpler inorganic substances
Humification (ह्यूमस भवन)	Accumulation of a dark-coloured amorphous substance called humus – highly **resistant to microbial action**, undergoes decomposition at an extremely slow rate. Being **colloidal** in nature, it serves as a **reservoir of nutrients**
Mineralisation (खनिजीकरण)	Humus is further degraded by some microbes & **release of inorganic nutrients** occurs

All the first three steps (fragmentation, leaching, catabolism) operate **simultaneously** on the detritus. Humification & mineralisation occur during decomposition in the **soil**.

Factors affecting rate of decomposition अपघटन दर को प्रभावित करने वाले कारक

- Decomposition is largely an **oxygen-requiring** process.
- Rate is controlled by **chemical composition of detritus** & **climatic factors**.

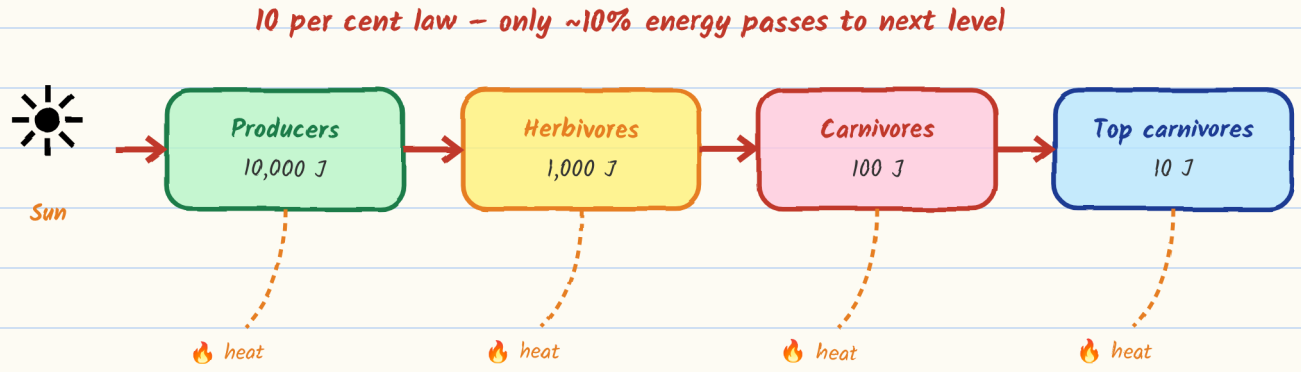
Faster decomposition ⬆	Slower decomposition ⬇
Detritus rich in **nitrogen** & water-soluble substances like **sugars**	Detritus rich in **lignin & chitin**
Warm & moist environment	**Low temperature & anaerobiosis** (no O_2) → build-up of organic materials

📌 **Exam Tip:** **Temperature & soil moisture** are the most important climatic factors that regulate decomposition through their effects on activities of soil microbes. Warm & moist environment favours decomposition, whereas low temperature & anaerobiosis inhibit it.

4. Energy Flow / ऊर्जा प्रवाह

- Except for the **deep sea hydro-thermal ecosystem**, **sun is the only source of energy** for all ecosystems on Earth.
- Of the incident solar radiation, less than 50% is photosynthetically active radiation (PAR).

- Plants & photosynthetic bacteria (autotrophs) fix sun's radiant energy to make food from simple inorganic materials. Plants capture only 2–10% of the PAR, & this small amount of energy sustains the entire living world.
- There is a unidirectional flow of energy from sun to producers & then to consumers.
- Ecosystems are not exempt from the **Second Law of Thermodynamics**. They need a constant supply of energy to synthesise molecules they require, to counteract the universal tendency towards increasing disorderliness.



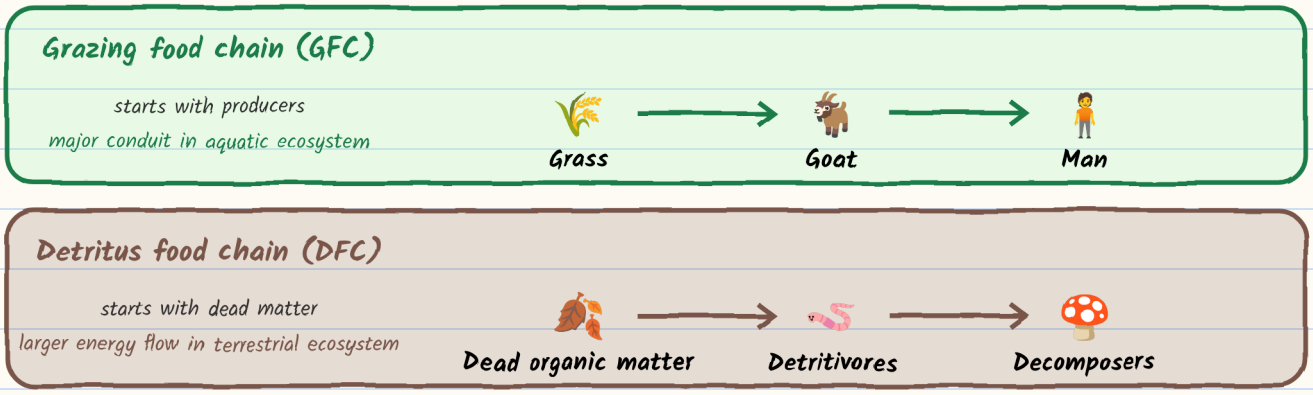
Infographic: Energy flow through trophic levels (10% law)

Producers & consumers उत्पादक व उपभोक्ता

- **Producers** – green plants. In terrestrial ecosystem: herbaceous & woody plants; in aquatic ecosystem: phytoplankton, algae & higher plants.
- All animals depend on plants (directly or indirectly) for food → called **consumers** & also **heterotrophs**.

Consumer	Feeds on	Example
Primary consumers (herbivores)	Producers (plants)	Insects, birds & mammals (terrestrial); molluscs (aquatic)
Secondary consumers (primary carnivores)	Herbivores	Frog, fox
Tertiary consumers (secondary carnivores)	Primary carnivores	Snake, wolf

Food chains खाद्य शृंखला



Infographic: Grazing vs Detritus food chain · चारण व अपरद खाद्य शृंखला

- **Grazing food chain (GFC)** (चारण खाद्य शृंखला): Grass → Goat → Man.
- **Detritus food chain (DFC)** (अपरद खाद्य शृंखला) begins with **dead organic matter**. Made up of **decomposers** – heterotrophic organisms, mainly **fungi & bacteria**. They meet their energy & nutrient requirements by degrading dead organic matter or detritus = saprotrophs (मृतजीवी) (sapro: to decompose). Decomposers secrete digestive enzymes that break down dead & waste materials into simple, inorganic materials, which are subsequently absorbed by them.
- In an **aquatic ecosystem**, **GFC** is the major conduit for energy flow. In a **terrestrial ecosystem**, a much larger fraction of energy flows through the **detritus food chain** than through the GFC.
- Detritus food chain may be connected with grazing food chain at some levels: some organisms of DFC are prey to GFC animals, & in a natural ecosystem some animals like cockroaches, crows, etc. are **omnivores**.

Food web & trophic levels खाद्य जाल व पोषण स्तर

- Natural interconnection of food chains makes it a food web (खाद्य जाल).
- Organisms occupy a place in the natural surroundings or in a community according to their feeding relationship with other organisms. Based on the source of their nutrition or food, organisms occupy a specific place in the food chain = their trophic level (पोषण स्तर).
- **Producers** – first trophic level; **herbivores** (primary consumers) – second; **carnivores** (secondary consumers) – third; and so on.
- Amount of energy **decreases at successive trophic levels**. When any organism dies, it is converted to detritus or dead biomass that serves as an energy source for decomposers.
- Organisms at each trophic level depend on those at the lower trophic level for their energy demands.

A simple food web · सरल खाद्य जाल

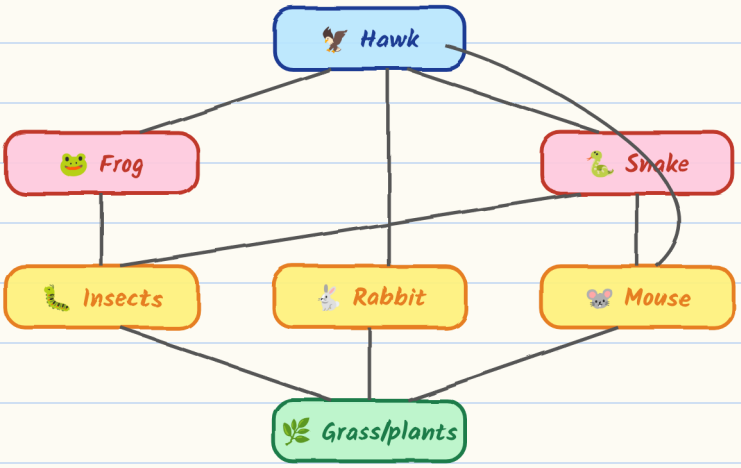


Fig: Food web – interconnected food chains (lines show feeding links, lower → higher level)

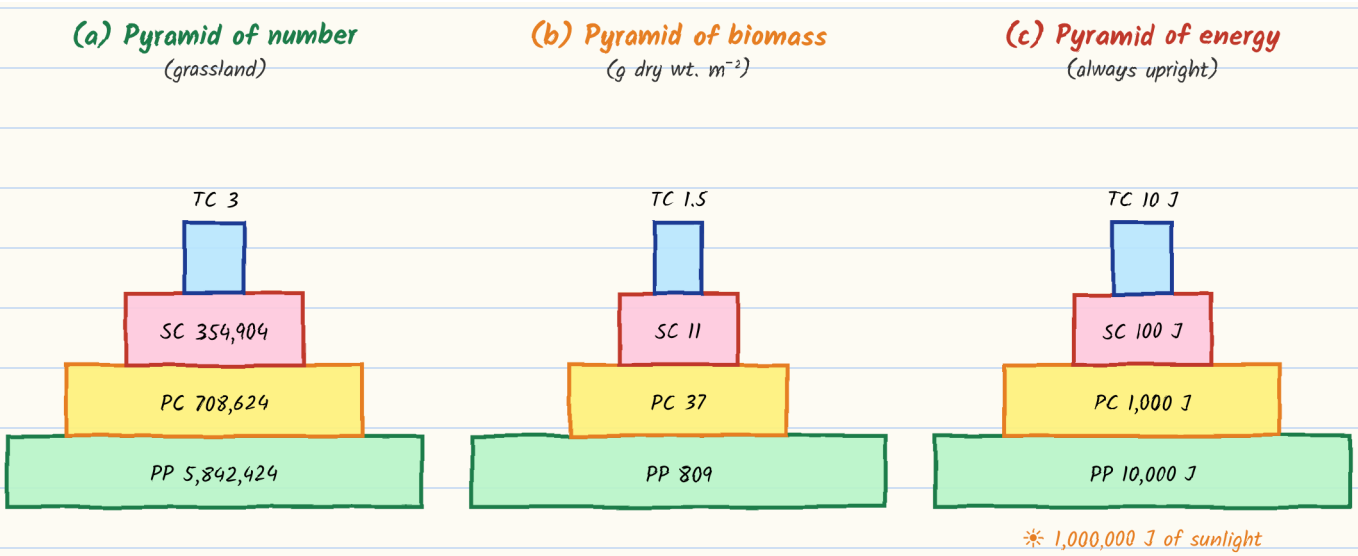
Standing crop & 10% law खड़ी फसल व 10% नियम

- Each trophic level has a certain mass of living material at a particular time = standing crop (खड़ी फसल).
- Standing crop is measured as the **biomass** of living organisms or the **number** in a unit area. Biomass of a species is expressed in terms of fresh or dry weight. Measurement of biomass in terms of **dry weight is more accurate**.
- Number of trophic levels in the grazing food chain is **restricted** as the transfer of energy follows the 10 per cent law – only **10 per cent of energy is transferred** to each trophic level from the lower trophic level.

Numerical: If producers have **20,000 J** energy → herbivores get 2,000 J → primary carnivores 200 J → secondary carnivores **20 J**.
उत्पादक 20,000 J → शाकाहारी 2,000 J → मांसाहारी 200 J → उच्च मांसाहारी 20 J

5. Ecological Pyramids / पारिस्थितिक पिरामिड

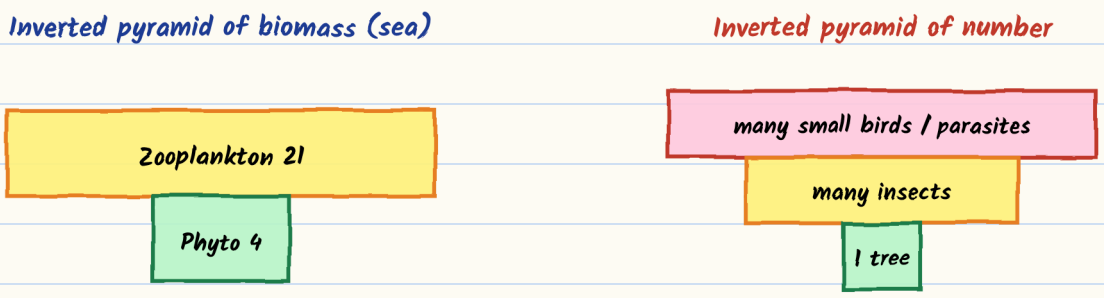
- The relationship between producers & consumers in an ecosystem can be graphically represented in the form of a pyramid = ecological pyramid.
- Base of each pyramid represents the **producers** or the first trophic level, while the apex represents **tertiary or top-level consumer**.
- Three types: **pyramid of number, pyramid of biomass & pyramid of energy**.
- For any calculation of energy content, biomass or number, it has to include **all organisms at that trophic level**. Energy content, biomass or number expressed in a **unit area**.
- Most ecological pyramids are **upright**, i.e. producers are more in number & biomass than herbivores, and herbivores are more than carnivores. Also, energy at a lower trophic level is always more than at a higher level.



PP – primary producer · PC – primary consumer · SC – secondary consumer · TC – tertiary consumer

Infographic: Upright ecological pyramids (NCERT values) · सीधे पारिस्थितिक पिरामिड

Inverted pyramids उल्टे पिरामिड



small standing crop of phytoplankton supports large standing crop of zooplankton (g m⁻² dry wt.) – फाइटोप्लैंकटन जल्दी पुनर्नवन

a single big tree supports thousands of insects

Pyramid of ENERGY is NEVER inverted

Infographic: Inverted pyramids · उल्टे पिरामिड

- In many cases, pyramid of biomass in the **sea** is **inverted**, because the biomass of fishes far exceeds that of phytoplankton. A small standing crop of **phytoplankton** supports a large standing crop of **zooplankton**.
- Pyramid of numbers can also be inverted, e.g. **insects feeding on a big tree**.
- Pyramid of energy is always upright, can never be inverted, because when energy flows from a particular trophic level to the next trophic level, **some energy is always lost as heat** at each step.
- Each bar in the energy pyramid indicates the amount of energy present at each trophic level in a given time or annually per unit area.

Limitations of ecological pyramids (पारिस्थितिक पिरामिड की सीमाएँ):

1. It does not take into account the **same species belonging to two or more trophic levels**.
2. It assumes a **simple food chain**, something that almost never exists in nature.
3. It does **not accommodate a food web**.
4. **Saprophytes** are not given any place in ecological pyramids even though they play a vital role in the ecosystem.

📌 **Important:** A given species may occupy more than one trophic level in the same ecosystem at the same time; e.g. a **sparrow** is a primary consumer when it eats seeds, fruits, peas, & a secondary consumer when it eats insects & worms. The trophic level represents a **functional level, not a species** as such.

⚡ Quick Revision / त्वरित पुनरावृत्ति

Keyword	Remember
Ecosystem	Functional unit of nature
Stratification	Trees → shrubs → herbs/grasses
Productivity units	g m^{-2} yr^{-1} or kcal m^{-2} yr^{-1}
NPP	GPP − R
Biosphere NPP	~170 billion tons; oceans 55 billion tons
Detritus	Dead plant & animal remains, fecal matter
Decomposition steps	Fragmentation, leaching, catabolism, humification, mineralisation
Humus	Dark, amorphous, colloidal; nutrient reservoir; slow decomposition
Slow decomposition	Lignin, chitin; cold; anaerobic
PAR	< 50% of incident solar radiation; plants capture 2–10%
GFC	Grass → Goat → Man; major in aquatic
DFC	Dead matter → decomposers; major in terrestrial
10% law	Only 10% energy transferred to next level
Standing crop	Mass of living material at a trophic level at a time
Inverted biomass	Sea: phytoplankton 4 → zooplankton 21
Never inverted	Pyramid of energy

⭐ Exam Corner / परीक्षा उपयोगी प्रश्न

1-Mark Questions 1M

Q1. Define ecosystem. / पारितंत्र की परिभाषा दीजिए।

→ Functional unit of nature where living organisms interact among themselves & with the physical environment.

Q2. What is stratification?

→ Vertical distribution of species at different levels (trees, shrubs, herbs).

Q3. Write the relation between GPP, NPP and R.

→ NPP = GPP − R.

Q4. What percentage of PAR is captured by plants?

→ 2–10%.

Q5. Why is earthworm called farmer's friend?

→ Fragments detritus & loosens soil, helping decomposition.

Q6. Which ecological pyramid is always upright?

→ Pyramid of energy.

Q7. Name the food chain through which a larger fraction of energy flows in terrestrial ecosystems.

→ Detritus food chain.

2/3-Mark Questions 2-3M

Q8. Differentiate between GPP and NPP.

→ GPP: total rate of organic matter production in photosynthesis; NPP: GPP minus respiration losses, available to heterotrophs.

Q9. Why is the productivity of oceans low despite covering 70% of the earth?

→ Only 55 of 170 billion tons; light decreases with depth & nutrients are limiting.

Q10. What is humus? Why is it important?

→ Dark amorphous substance from humification; resistant, colloidal; reservoir of nutrients.

Q11. Name the factors that regulate decomposition and how.

→ Chemical composition (N, sugars fast; lignin, chitin slow); temperature & moisture (warm, moist fast; cold, anaerobic slow).

Q12. Differentiate between grazing and detritus food chain.

→ Begins with producers vs dead organic matter; major in aquatic vs terrestrial.

Q13. If producers fix 50,000 J, how much energy reaches tertiary consumers (10% law)?

→ 50,000 → 5,000 (PC) → 500 (SC) → 50 J (TC).

Q14. Why is the pyramid of biomass inverted in the sea?

→ Small standing crop of phytoplankton (fast turnover) supports larger biomass of zooplankton/fish.

Q15. Why is energy flow unidirectional?

→ Energy passes sun → producers → consumers; lost as heat at each level, never returns.

5-Mark Questions SM ★★★

Q16. Describe the steps of decomposition and the factors affecting its rate.

→ Fragmentation, leaching, catabolism, humification, mineralisation; chemical composition & climatic factors.

Q17. Explain energy flow in an ecosystem. Why is the number of trophic levels limited?

→ PAR, 2–10% capture, unidirectional flow, 2nd law, GFC/DFC, 10% law → energy too little after 4–5 levels.

Q18. What are ecological pyramids? Describe the three types with diagrams. Mention their limitations.

→ Number, biomass, energy (with NCERT values); inverted cases; 4 limitations.

Q19. Describe the structure and functions of a pond ecosystem.

→ Abiotic, producers, consumers, decomposers; productivity, decomposition, energy flow, nutrient cycling.

✏ **Diagrams to practise / अभ्यास हेतु चित्र:**

1. Decomposition cycle (diagrammatic) ⭐
2. Energy flow through trophic levels ⭐
3. Pyramids of number, biomass & energy ⭐
4. Inverted pyramid of biomass

🎯 **Last-minute tips:** Learn the 5 decomposition steps in order (**F-L-C-H-M**: "Fresh Leaves Can Help Me") · Always write units of productivity · In pyramid questions, state "energy pyramid is never inverted because energy is lost as heat" · 10% law numericals – divide by 10 at each step.

~ All the best! / शुभकामनाएँ! ~