Land and Water Use

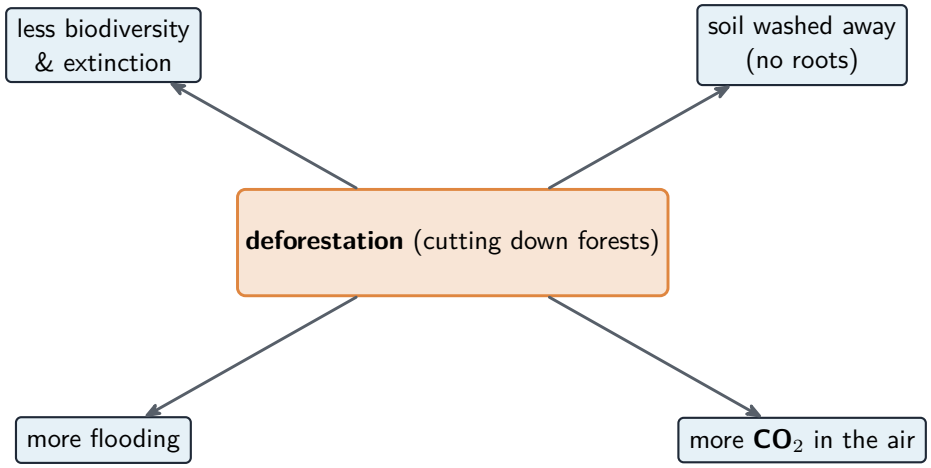
AP Environmental Science

The Tragedy of the Commons

The **tragedy of the commons** 公地悲剧: when a resource is shared and open to all (a fishery, the atmosphere, a pasture), each user takes as much as they can for private gain, and the shared resource is overused and degraded for everyone. Solutions require regulation, privatization, or cooperative management.

Clearcutting

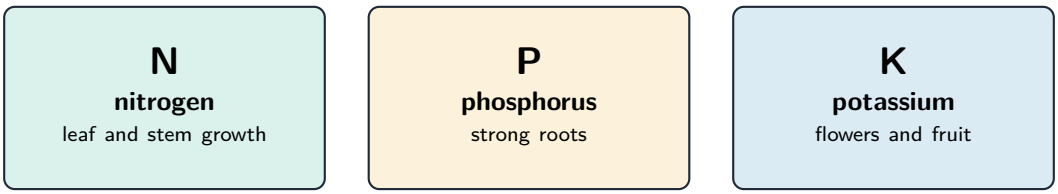
Clearcutting 皆伐 removes all trees from an area at once. It is cheap and efficient but causes **erosion** 侵蚀, loss of habitat and biodiversity, flooding, and higher soil temperatures. Recovery is slow, and nearby streams suffer from sediment.



Deforestation lowers biodiversity and causes erosion, flooding, and higher CO2

The Green Revolution

The **Green Revolution** 绿色革命 boosted crop yields with high-yield seeds, **synthetic fertilizers** 化肥, **pesticides** 农药, irrigation, and mechanization. It fed billions but brought costs: soil degradation, water pollution, high energy and water use, and loss of crop diversity (**monoculture** 单一栽培).



NPK fertilisers contain all three - ammonium salts and nitrates supply the nitrogen

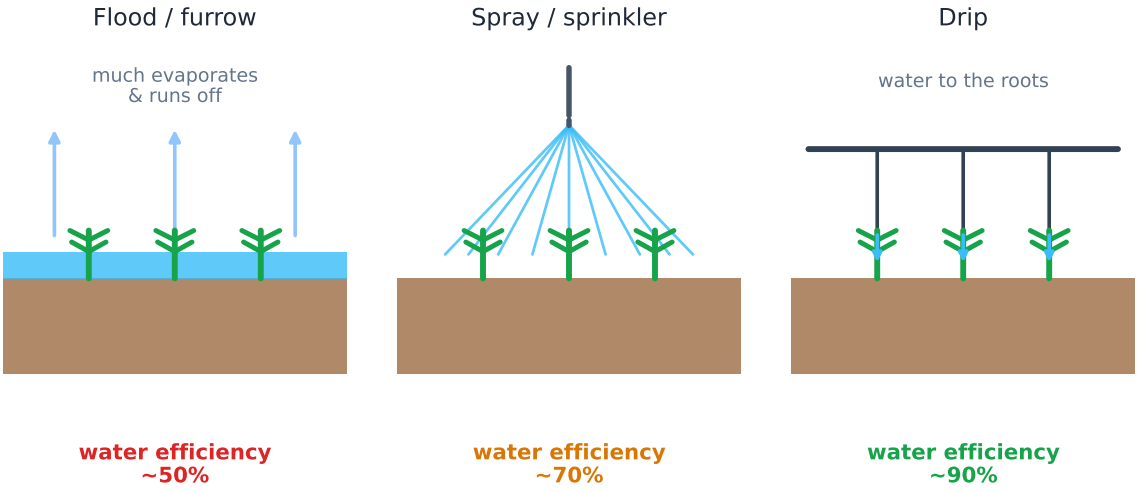
NPK fertilisers supply the three elements plants need most

Impacts of Agricultural Practices

Practices such as tilling, monoculture, and heavy fertilizer/pesticide use cause **erosion**, **soil salinization** 土壤盐碱化, nutrient runoff (causing **eutrophication** 富营养化), and loss of biodiversity. Sustainable methods reduce these harms.

Irrigation Methods

Irrigation 灌溉 supplies water to crops. **Drip** irrigation is the most efficient (least evaporation); **flood** and **spray** methods waste more water and can cause **waterlogging** and **salinization** as evaporation leaves salts behind. Over-irrigation depletes aquifers.



Irrigation methods compared: drip wastes the least water, flooding the most

Pest Control Methods

Pesticides kill pests and raise yields, but cause problems: they harm non-target species, pollute water, and drive **pesticide resistance** 抗药性 (survivors breed, so stronger doses are needed –the "pesticide treadmill").

Meat Production Methods

Producing meat, especially in **concentrated animal feeding operations** (CAFOs), uses large amounts of land, water, feed, and energy, and generates waste and **methane** 甲烷 (a greenhouse gas). Meat is far less energy-efficient than plant food because of the 10% rule –higher trophic levels waste more energy.

Impacts of Overfishing

Overfishing 过度捕捞 removes fish faster than they reproduce, collapsing populations (like cod). **Bycatch** (unwanted catch) and destructive methods (bottom trawling) damage ecosystems. It is a classic tragedy of the commons in the open ocean.

Impacts of Mining

Mining 采矿 extracts minerals and fuels but disturbs land, especially **surface (strip) mining** and **mountaintop removal**. Impacts include habitat destruction, **acid mine drainage** 酸性矿山废水, and toxic tailings polluting water.

Impacts of Urbanization

Urbanization 城市化 replaces natural land with **impervious surfaces** 不透水面 (roads, buildings), increasing runoff and flooding, creating **urban heat islands** 热岛, and generating pollution and waste. **Urban sprawl** consumes farmland and habitat.

Ecological Footprints

An **ecological footprint** 生态足迹 measures the land and water a person or population needs to supply resources and absorb wastes. Wealthy, high-consumption nations have much larger footprints. If everyone's footprint exceeds Earth's capacity, resources are being used unsustainably.

Worked example. Earth provides roughly 1.6 global hectares (gha) of **biocapacity** per person. If the average person's footprint is 2.7 gha, humanity is demanding about $\frac{2.7}{1.6} \approx 1.7$ Earths –living beyond what the planet can renew. Worse, if everyone consumed like a high-income nation at 8 gha per person, it would take $\frac{8}{1.6} = 5$ Earths –exactly why footprint-per-person is the key sustainability yardstick.

Introduction to Sustainability

Sustainability 可持续性 means meeting present needs without harming future generations' ability to meet theirs. It balances environmental health, economic viability, and social equity, using resources no faster than they can be replaced.

Methods to Reduce Urban Runoff

Reduce runoff with **permeable pavement** 透水路面, **rain gardens** and **green roofs** 绿色屋顶, retention ponds, and preserved vegetation. These let water soak in, filtering pollutants and recharging groundwater instead of flooding streams.

Integrated Pest Management

Integrated pest management 综合虫害管理 (IPM) combines methods –biological controls (natural predators), crop rotation, limited targeted pesticides, and monitoring –to control pests with **less** chemical use, slowing resistance and protecting non-target species.

Sustainable Agriculture

Sustainable farming protects soil and water: **crop rotation** 轮作, **cover crops**, **contour plowing** 等高耕作, **terracing** 梯田, reduced tillage, and **agroforestry**. These cut erosion, maintain fertility, and reduce chemical inputs.

Aquaculture

Aquaculture 水产养殖 (fish farming) eases pressure on wild stocks and is efficient, but can pollute water with waste and antibiotics, spread disease to wild fish, and destroy habitat (like mangroves for shrimp farms).

Sustainable Forestry

Sustainable forestry keeps forests productive: **selective cutting** 择伐 instead of clearcutting, replanting, leaving buffer strips along streams, and long rotation times. It maintains habitat, prevents erosion, and lets forests keep providing ecosystem services.

Exam tips

- Explain the **tragedy of the commons** —shared, unowned resources get overused —and how rules/ownership prevent it.
- Weigh the trade-offs of the green revolution, irrigation (salinisation, aquifer depletion), and mining/urbanisation.
- Compute an **ecological footprint** in "number of Earths" (footprint ÷ biocapacity per person); it is measured **per person**.
- List the harms of **deforestation** (erosion, flooding, lost habitat, more CO).
- Define **sustainability** (meeting needs without harming future generations) and give sustainable methods (IPM, crop rotation, quotas).