Land and Water Use

AP Environmental Science ▪ Unit 5

AP Environmental Science

What we will cover

1 Commons

The tragedy of the commons

A shared **common resource** 公共资源 open to all tends to be over-used:

- the gain goes to one user
- the cost is shared by all

> Fix it with **regulation** 管制 (catch limits) or **private ownership** 私有制 (owner protects it).

Open pit mine

2 Agriculture

Agriculture and food

The **Green Revolution** 绿色革命 raised yields with high-yield crops, fertilizer, irrigation, mechanization, and monoculture.

> Costs: eutrophication, desertification, lost biodiversity.

Intensive farmland: high yield, high impact

What intensive farming costs

Tillage, fertilisers and monoculture raise yields – and erode soil

Tilling, **monoculture** 单一栽培 and heavy fertiliser and pesticide use cause:

- erosion and **soil salinization** 土壤盐碱化;
- nutrient runoff, driving **eutrophication** 富营养化;
- loss of biodiversity.

Meat, grazing and desertification

CAFOs 集中动物饲养场 use large amounts of land, water, feed and energy, and generate waste and **methane** 甲烷. Meat is far less energy-efficient than plant food: the 10% rule means every trophic level wastes more energy.

Overgrazing 过度放牧 – livestock eating vegetation faster than it regrows – strips the soil's protective cover. On dry land that drives **desertification** 荒漠化.

> The answer is **rotational grazing** 轮牧: move the livestock so no area is grazed bare.

3 Water

Irrigation and water

Irrigation methods 灌溉方法 differ in waste:

- **flood** 漫灌 wastes most; **drip** 滴灌 wastes least

> Over-watering causes **salinization** 盐碱化 and **aquifer depletion** 含水层枯竭.

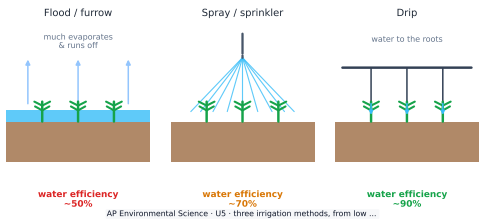
Rice terraces

Irrigation is the largest human use of fresh water

the figure	about 70% of world freshwater use – the exam expects this number
aquifers 含水层	underground stores; pumped faster than they refill, the water table falls
saltwater intrusion 海水入侵	over-pumping near a coast lets sea water move into the aquifer, ruining it for drinking and crops
the hydrologic cycle 水循环	irrigation diverts water out of it; **waterlogging** 涝渍 and **salinization** 盐碱化 follow poor drainage

> Every irrigation question is the same trade: more crop now against a falling water table and a saltier soil later.

Irrigation methods, and what each costs



> Flood irrigation is cheap and wasteful; drip delivers water to the root and wastes least. The trade-off is always cost against water lost.

4 Pests

Pest control and IPM

Two approaches to pests:

- **chemical** 化学的: fast, but breeds **pesticide resistance** 抗药性
- **biological** 生物的: natural predators, no poison

> **IPM** 病虫害综合治理: monitor first, spray last.

Chemical control: fast, but resistance rises

What pesticides cost, and what IPM does instead

pesticides 农药	raise yields, but harm non-target species and pollute water
pesticide resistance 抗药性	survivors breed, so stronger doses are needed – the pesticide treadmill
integrated pest management 综合虫害管理	IPM: biological controls (natural predators), crop rotation, limited targeted pesticide, and monitoring
why IPM wins	lower cost and lower environmental damage, and it does not breed resistance the way blanket spraying does

> IPM is not 'no pesticides'. It is pesticide as the last tool rather than the first.

5 Harvest

Harvesting resources

Take renewables no faster than they regrow – the **sustainable yield** 可持续产量.

- **clearcutting** 皆伐 erodes; selective cutting sustains
- mining: acid drainage + tailings; reclaim afterward

Clearcutting: short yield, long erosion

Overfishing and aquaculture

Overfishing 过度捕捞 removes fish faster than they reproduce, collapsing populations – cod is the standing example. **Bycatch** 兼捕 and bottom trawling damage the ecosystem as well as the target stock.

> The open ocean is the classic tragedy of the commons: no one owns the fish.

Aquaculture 水产养殖 eases pressure on wild stocks and is efficient, but it can:

- pollute water with waste and antibiotics;
- spread disease to wild fish;
- destroy habitat – mangroves cleared for shrimp farms.

Mining

Benches cut ever wider and deeper to reach the ore

Surface (strip) mining 露天开采 and mountaintop removal disturb the most land. Impacts:

- habitat destruction;
- **acid mine drainage** 酸性矿山废水;
- toxic tailings polluting water.

When easy deposits run out, mining goes **subsurface** 地下开采 – costlier and more dangerous. Coal follows the same path.

Conservation methods, and what happens when the easy ore runs out

contour plowing 等高耕作	ploughing across a slope, not down it, so furrows hold water instead of channelling it
terracing 梯田	cutting a hillside into level steps – steep land farmed without losing the soil
windbreaks 防风林	rows of trees that slow the wind before it lifts topsoil
subsurface mining 地下开采	once easily reached deposits are gone, mining goes underground: far more expensive and dangerous

The same pattern runs through the whole unit: the cheap, easy resource is taken first, and every later unit costs more to get.

6 Cities

Urbanization and sustainability

Urbanization 城市化 adds **impervious surfaces** 不透水面:

- more runoff, less recharge; heat island; sprawl
- fix with permeable pavement, green roofs

An ecological footprint above biocapacity cannot last.

Sprawl: impervious surfaces and heat islands

What a city does to the land it covers

impervious surfaces 不透水面	roads and buildings replace soil, so rain runs off instead of soaking in – more flooding, less recharge
urban heat islands 城市热岛	dark surfaces and waste heat leave a city several degrees warmer than the land around it
urban sprawl 城市蔓延	low-density spread consumes farmland and locks in car dependence
synthetic fertilizers 合成肥料	from the surrounding farms, carried into the city's rivers by that same runoff

Runoff is the link: pave the ground and you change the flood risk, the groundwater, and what reaches the river, all at once.

Reducing urban runoff

- **permeable pavement** 透水路面
- **rain gardens** 雨水花园 and **green roofs** 绿色屋顶
- retention ponds, and preserved vegetation

Each one lets water soak in – filtering pollutants and recharging groundwater instead of flooding the stream all at once.

Ecological footprints

An **ecological footprint** 生态足迹 is the land and water one person needs to supply their resources and absorb their wastes.

Wealthy, high-consumption nations have much larger footprints. Footprint per person is the yardstick.

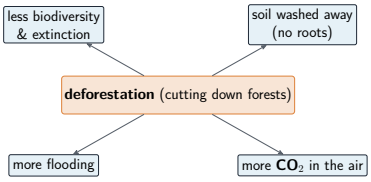
How many Earths?

Earth provides about 1.6 global hectares (gha) of **biocapacity** 生态承载力 per person.

$\frac{2.7}{1.6} \approx 1.7$ Earths at the world average,

$\frac{8}{1.6} = 5$ Earths if everyone lived at 8 gha.

Sustainable forestry



Selective cutting 择伐 instead of clearcutting, replanting, buffer strips along streams, long rotations. Forests store CO_2, so cutting and burning them releases it. Mitigate with **reforestation** 重新造林, sustainably sourced wood, and reuse.

A **prescribed burn** 计划烧除 is a separate tool: burn under control to clear fuel, so a later wildfire cannot grow catastrophic.

The Green Revolution

N **nitrogen** leaf and stem growth

P **phosphorus** strong roots

K **potassium** flowers and fruit

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).

Introduction to Sustainability

Wind turbines on farmland: sustainable resource use meets present needs without locking out future generations

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).

7 Recap

Worked example – the tragedy of the commons

A shared pasture supports 100 cattle. Each of 10 herders adds one more animal. Explain the outcome.

- The benefit of an extra animal goes entirely to one herder.
- The cost – overgrazing – is shared by all ten.
- So it is rational for each to add one, though all lose: 110 cattle exceed the carrying capacity.
- The grass fails ⇒ the resource collapses and everyone is worse off.

The tragedy needs an open-access resource with private gain and shared cost. Fixes: regulate, privatise, or agree limits – as with fisheries and the atmosphere.

Unit 5 – key takeaways

1. **Commons** — gain to one, cost to all; regulation or ownership
2. **Food & water** — Green Revolution trade-offs; drip beats flood
3. **Pests & harvest** — IPM over spraying; sustainable yield
4. **Cities** — impervious runoff, heat island; footprint vs biocapacity

Check yourself

1. In the commons, who gets the gain and who pays the cost?
2. Which irrigation method wastes the least water?
3. What does IPM do before spraying pesticide?
4. Name the three pillars of sustainability.

Answers **1.** gain to one user, cost shared by all **2.** drip **3.** monitor pest numbers **4.** economic, social, environmental