Unit 15 · Ecological Imbalances

STUDY NOTES

WHAT NEB'S GRADE 11 EXAM ASKS

- **CDC's grid (2077):** Ecology (Units 13–15 together): 6 of 75 marks, 1 short answer and 1 MCQ; with Floral Diversity and Vegetation a combined 26
- **The paper:** 11 MCQs × 1 · 8 short × 5 · 3 long × 8; 3 hours; 1 mark per expected point
- **MCQ (1 mark)**
  - most abundant greenhouse gas (water vapor); not a greenhouse gas (N_2)
  - source of methane (rice fields, cattle); layer with most ozone (stratosphere)
  - bromine to the ozone layer (halons); gases of acid rain (SO_2, NO_x)
  - exotic vs invasive (potato); what helps an invader most
- **Short (in parts)**
  - greenhouse gases and how human activity raises them; mitigation
  - ozone layer depletion and its consequences
  - formation of acid rain
  - biological invasion; native, exotic, invasive; control measures

Key terms

Ecological imbalance: disturbance of an ecosystem's natural equilibrium.

Greenhouse effect: greenhouse gases trap the **infrared** given out by the Earth's surface, warming it.

Global warming: warming from the **enhanced** greenhouse effect; **climate change**: the changes in weather and climate it brings.

Ozone layer: O_3 in the **stratosphere** (15–35 km, ~90 % of ozone); absorbs UV-B, UV-C.

Ozone layer depletion: thinning; ozone destroyed faster than made.

ODS: ozone-depleting substances.

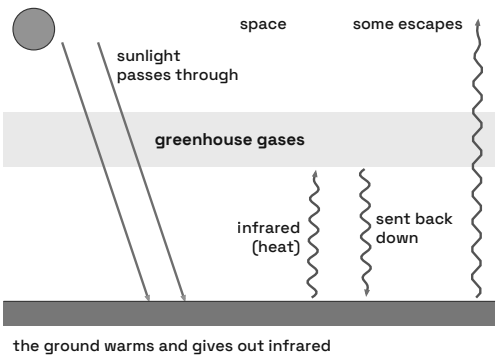
Acid rain: rain, snow, fog or dust acidic from **sulphuric and nitric acids** formed from pollutants; pH usually 4–5.

Biological invasion: introduction, establishment and spread of a species where it is not native.

Native species: naturally there for long; **exotic** (alien): brought by people; **invasive alien**: exotic that spreads on its own and harms.

Greenhouse effect and climate change

- sunlight passes through the air → surface absorbs, warms → gives out **infrared** → greenhouse gases absorb it, send part back down
- natural, needed: without it ~−18 °C, not ~15 °C
- gases traps **heat (infrared)**, not sunlight



Sunlight in; the ground gives out infrared; greenhouse gases send part back; some escapes.

Greenhouse gases

- **water vapor**: most abundant; changed only indirectly (warmer air holds more)
- **CO_2**: burning coal, oil, gas; cutting, burning forests; cement
- **CH_4** (methane): flooded rice fields, cattle, buffaloes, goats, landfills, gas leaks
- **N_2O** (nitrous oxide): nitrogen fertilizers, manure
- CO_2 at Mauna Loa: 316 ppm (1959) → 427 ppm (2025)
- Venus: ~96 % CO_2, ~464 °C, hotter than Mercury

Useful consequences

- natural effect keeps the Earth warm

- greenhouses: **tropical plants** in cold regions; **off-season** crops (plastic tunnels: Kathmandu, Jumla, Mustang)

Harmful consequences (global warming)

1. **sea level rises**: thermal expansion, melting ice
2. **extreme weather**: heat waves, heavy rain, floods, storms, **droughts**
3. species **move** towards poles, up mountains
4. **new pests, diseases**
5. species **vulnerable to extinction**
6. **invasive species** increase

- Nepal: glaciers shrinking; glacial lakes (Imja lowered 3.4 m, 2016); dengue now in hills, Kathmandu

Mitigation

1. **reduce emissions**: hydro, solar, wind instead of fossil fuels
2. **forests**: carbon **sequestration**, afforestation, less deforestation; community forests
3. **electric** or low-emission vehicles (Nepal's electricity from water)
4. waste less; **biogas** captures methane

Ozone layer depletion

- UV splits $O_2 \rightarrow$ atoms + $O_2 \rightarrow O_3$; O_3 absorbs UV, splits; balance
- UV: **skin cancer**, **cataracts**; harms crops, plankton

Causes: ODS

- **CFCs**: refrigerators, air conditioners, foam, aerosol sprays
- **halons**: fire extinguishers (**bromine**, faster than chlorine)
- **methyl bromide** (pesticide), **carbon tetrachloride** (solvent)
- stable → rise to stratosphere → UV frees **chlorine, bromine atoms** → **catalysts**
  - $Cl + O_3 \longrightarrow ClO + O_2$
  - $ClO + O \longrightarrow Cl + O_2$
  - Cl regenerated: one atom destroys **> 100,000** O_3
- **ozone hole** over Antarctica each southern spring

Consequences

1. **skin cancer**, **cataract**
2. **immune system** suppressed
3. **plants**: less photosynthesis, stunted, lower yields; phytoplankton harmed
4. atmospheric **circulation** changes → climate
5. **economic** costs: health, crops, plastics and paints weakened

Mitigation

1. **stop ODS**; safer substitutes; **Montreal Protocol** (**1987**; Nepal 1994); recovery to 1980 level **~2040** (most of the world), 2045 Arctic, 2066 Antarctica
2. **cut N_2O**: now the largest ozone-depleting emission; careful fertilizer, legumes, compost

- Molina and Rowland (1974) warned about CFCs; ozone hole found 1985; Nobel 1995 with Crutzen

Acid rain

- clean rain **pH ~5.6** ($CO_2 \rightarrow$ weak carbonic acid); acid rain pH **4–5**

Causes

- **SO_2** and **NO_x** (NO, NO_2) from coal, oil: power plants, factories, brick kilns, vehicles
- $2\,SO_2 + O_2 \longrightarrow 2\,SO_3$; $SO_3 + H_2O \longrightarrow H_2SO_4$
- $4\,NO_2 + O_2 + 2\,H_2O \longrightarrow 4\,HNO_3$
- falls far (hundreds of km) from the source

Effects

1. **surface water**: acidic lakes; fish eggs, young fish die; aluminium poisons gills
2. **soils**: calcium, magnesium washed out; microorganisms killed
3. **forests, plants**: leaves damaged, growth slowed, trees die (mountains in acid cloud)
4. **health**: the gases and fine particles → **asthma**, **bronchitis**; acid fog irritates eyes, airways (touching acid rain is harmless)
5. **buildings, monuments**: **limestone, marble** eaten; metals corroded
   - $CaCO_3 + H_2SO_4 \longrightarrow CaSO_4 + CO_2 + H_2O$

Control

1. **reduce SO_2, NO_x**: emission standards, low-sulphur fuel, **scrubbers**, **catalytic converters**, renewables
2. **liming** lakes, soils (repair, must be repeated)
3. **awareness**

- USA: power-plant SO_2 down > 90 % (1990–2019); lakes recovered

Biological invasion

- **exotic** but harmless: potato, maize, tomato (from the Americas)

Features of invasive species

1. **fast growth, reproduction**
2. **tolerate** a wide range, disturbed places
3. **few predators, diseases** (left at home)
4. **aggressive competition**: light, water, nutrients, space
5. **efficient dispersal**: light seeds, hooks, pieces that root

Causes of spread (mostly human)

1. **globalization, trade**: ship **ballast water**, goods, grain, soil, vehicles
2. **accidental release**: pets, farm escapes, garden plants
3. **land-use change**: cleared, burnt, overgrazed land; roadsides
4. **climate change**

Impacts

1. **ecosystems disturbed**: natives crowded out; new predators, diseases; soil microbes, habitat changed
2. **economic**: lower yields, control costs, choked lakes, canals, hydropower intakes
3. **health**: diseases; allergies (*Parthenium*)
4. **loss of biodiversity**

Management

1. **prevention**: inspect cargo, **quarantine**
2. **early detection, rapid response**
3. **control**: **mechanical** (uproot, cut), **chemical** (herbicides, carefully), **biological** (a tested natural enemy)
4. **public awareness**

- use them: water hyacinth → baskets, mats, compost; *Lantana* → furniture

In Nepal: ~182 naturalized alien flowering plants, ~27 invasive (2021); four among the **world's 100 worst**: *Mikania*, *Chromolaena*, *Lantana*, water hyacinth

Species	Common name	Home	Harm
Mikania micrantha	lahare banmara	Central, South America	climber smothers trees, grassland (Chitwan)
Ageratina adenophora	banmara	Mexico	hill pastures, forest edges; harms livestock
Lantana camara	kirne kanda	tropical America	thorny thickets; poisonous to cattle
Parthenium hysterophorus	paati jhar	tropical America	fields, roadsides; skin allergy, asthma; lower yields
Eichhornia crassipes	jalkumbhi	South America	covers Phewa, Begnas; blocks light, oxygen
Oncorhynchus mykiss	rainbow trout	western North America	may compete with snow trout if wild
Pomacea	golden apple snail	South America	pest of young rice

COMMON MISTAKES

✗ The greenhouse effect traps sunlight
✓ it traps **infrared** from the warmed Earth.

✗ The greenhouse effect is all harmful
✓ natural effect keeps Earth ~15 °C; the **enhanced** effect harms.

✗ CO_2 is the most abundant greenhouse gas
✓ **water vapor** is.

✗ Global warming helps new species evolve
✓ far too slow; it pushes species to **extinction**.

✗ UV releases "chlorides and bromides"
✓ free chlorine and bromine **atoms**.

✗ Any rain with a pH below 7 is acid rain
✓ clean rain is pH ~5.6; acid rain is **below 5.6**.

✗ Every exotic species is invasive
✓ only those that **spread on their own and harm**.