Climate Change and Sustainable Agriculture

Concept, Causes, Consequence and Adaptation

What is Climate Change?

- Climate is the average weather over a long period (typically 30 years).
- We expect the weather to change a lot from day to day, but we expect the climate to remain relatively constant.
- If the climate doesn't remain constant, we call it climate change.
- The key question is what is a significant change – and this depends upon the underlying level of climate variability

Climate Change History

- Earth's climate has always been changing
  - Ice age (2 million years ago), glacial periods, polar ice caps
  - 18,000 years ago: cold spell & continental glaciers

- Last 100 yrs, surface has warmed about 0.6°C
- In past 10,000 yrs, global temp. has never varied more than 1.5°C

Climate Change

3 important changes.....

- Temperature Change
- Precipitation Change
- Sea Level Rise

Causes of Climate change

Natural

- Explosions on the sun ("sun spots")
- Volcanic eruptions on a massive scale
- Changes in earth orbit
- Changes in earth's orientation toward the sun
- Explosions caused by large meteors hitting the earth

Man made

- Greenhouse effect

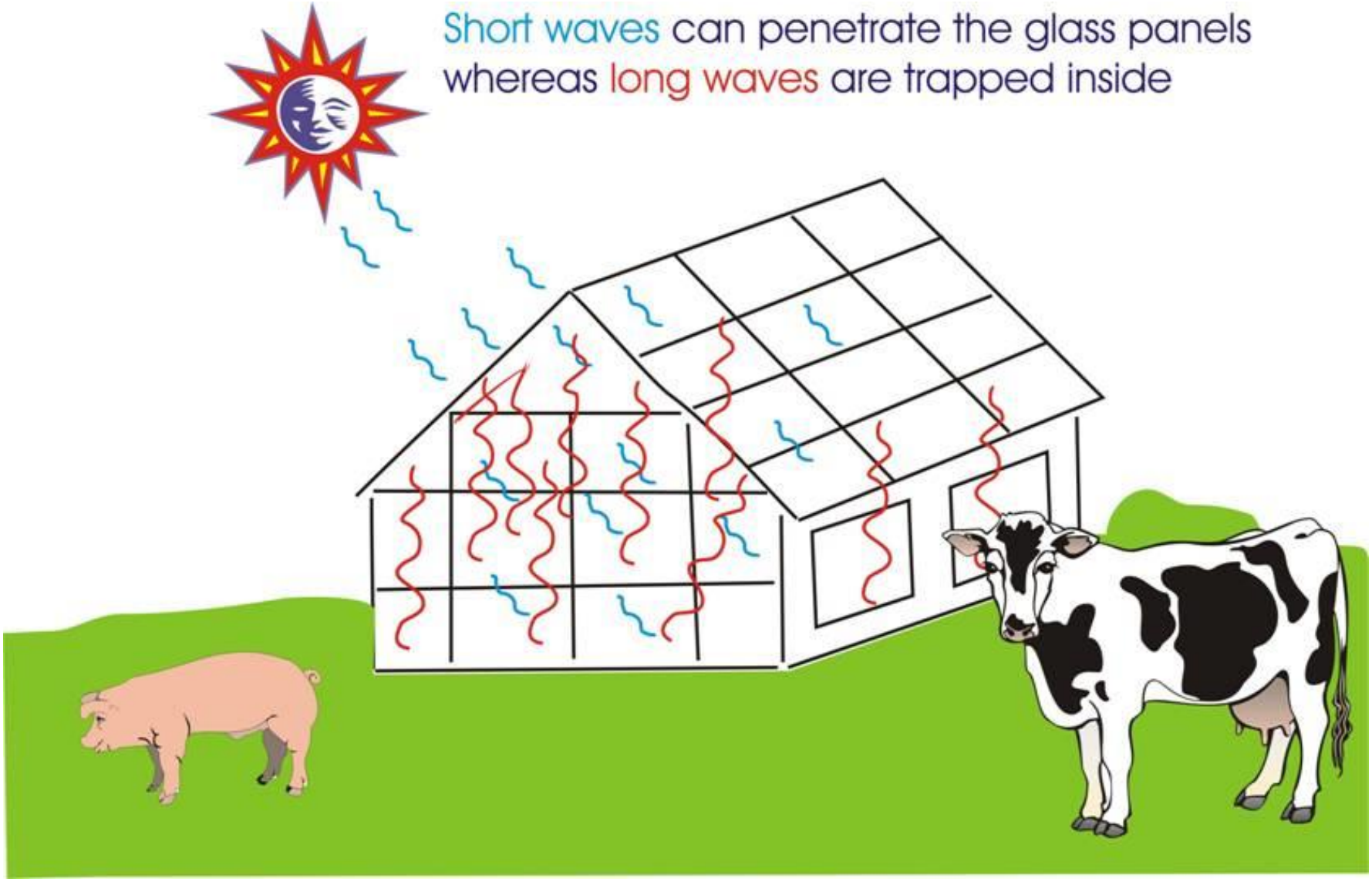
Sun

Greenhouse Effect

Definition of Greenhouse Effect

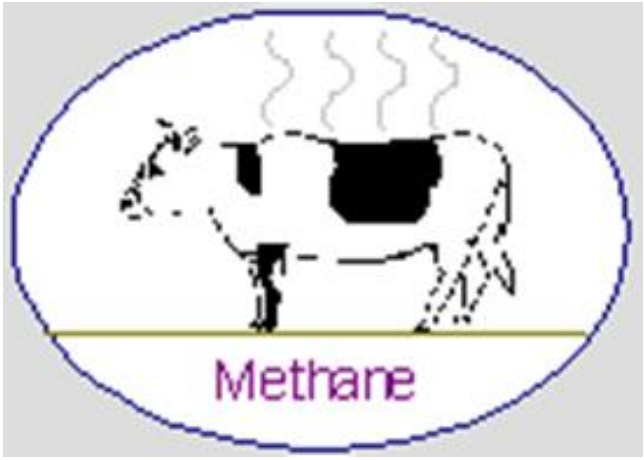
The greenhouse effect is the natural warming of the lower atmosphere (troposphere) because of the presence of **certain gases (Greenhouse gases)** by trapping more heat energy.

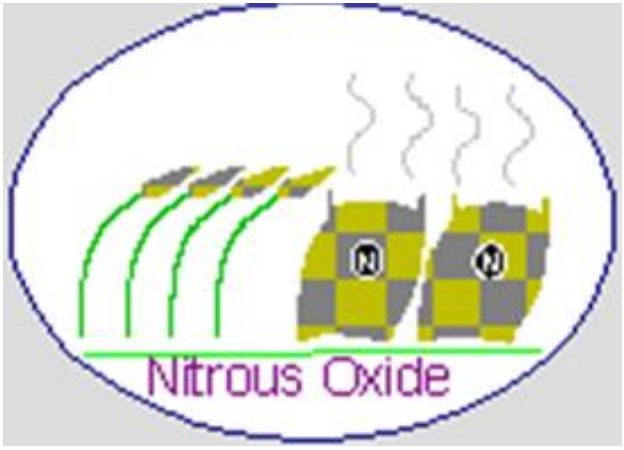
The real greenhouse



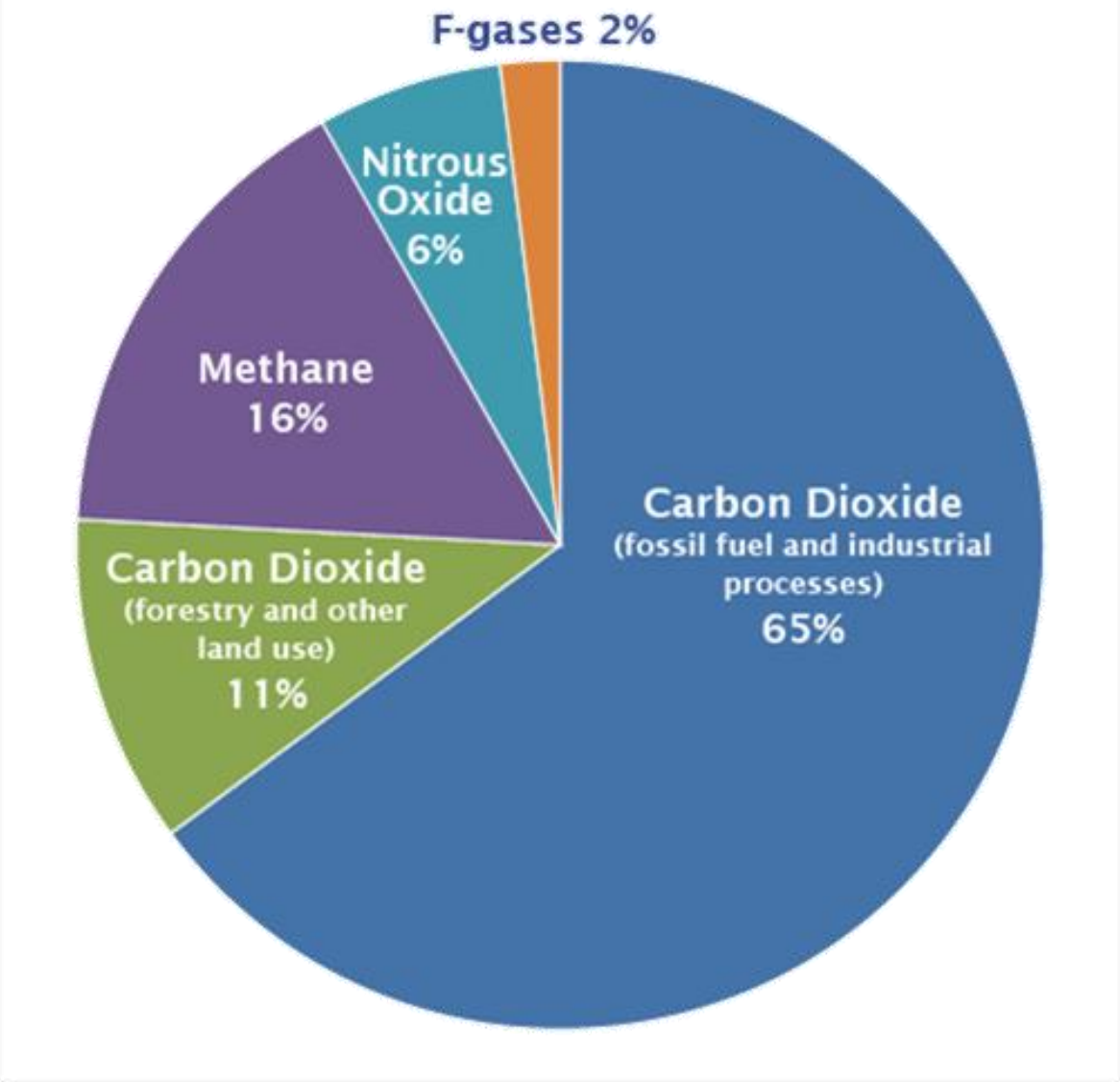
Increasing greenhouse gases trap more heat

Greenhouse gases

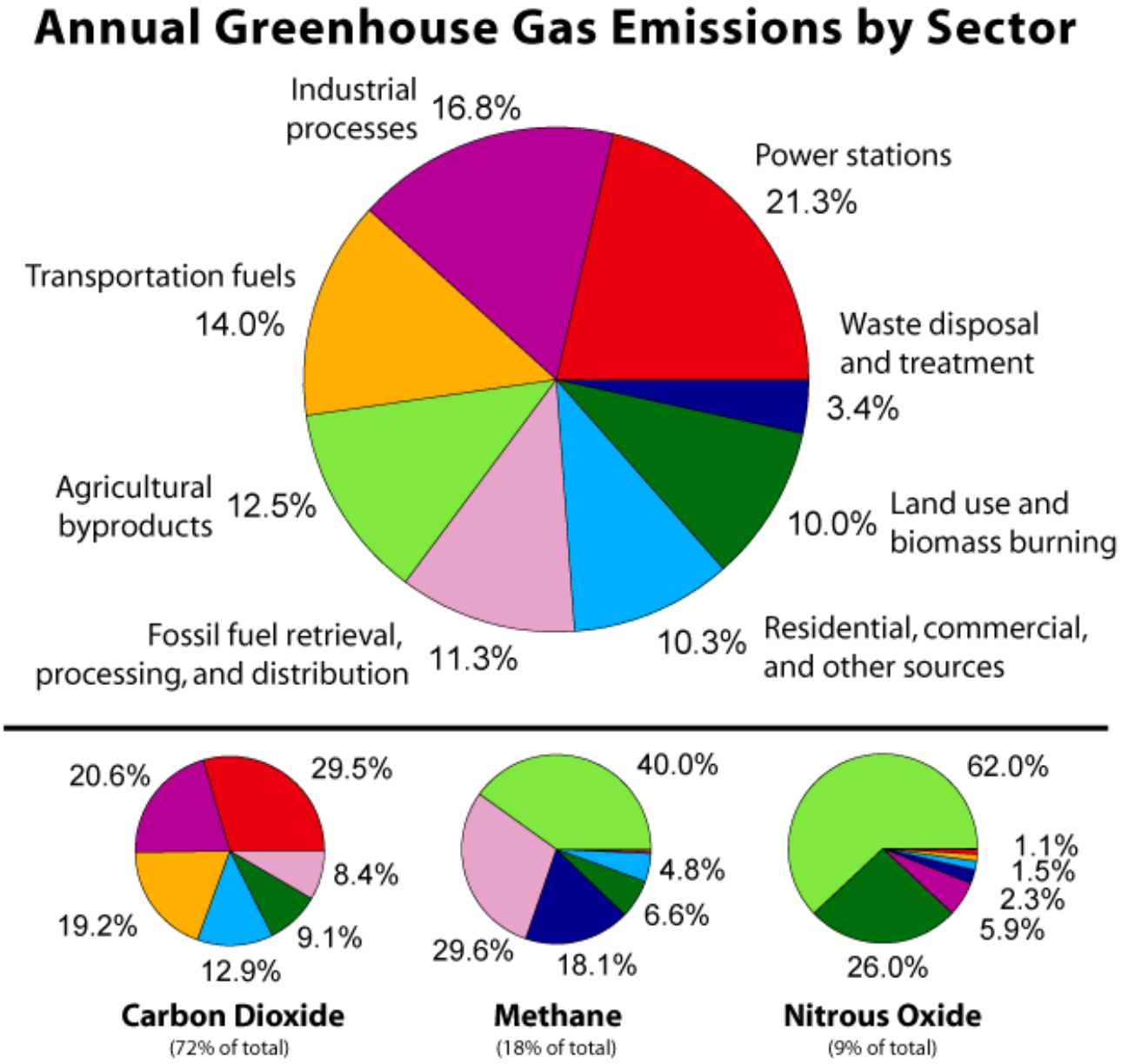




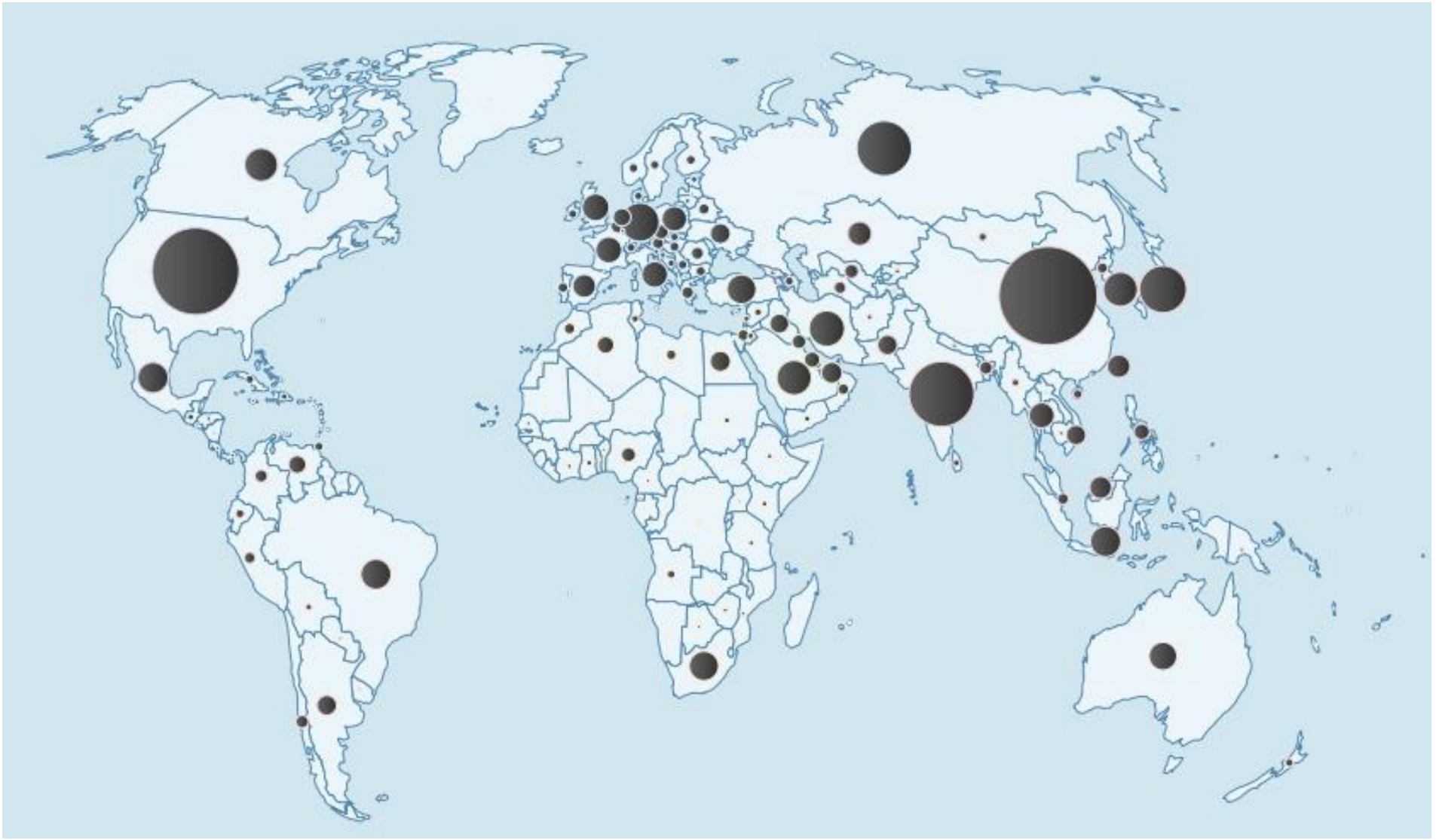
Relative proportion of anthropogenic greenhouse gases



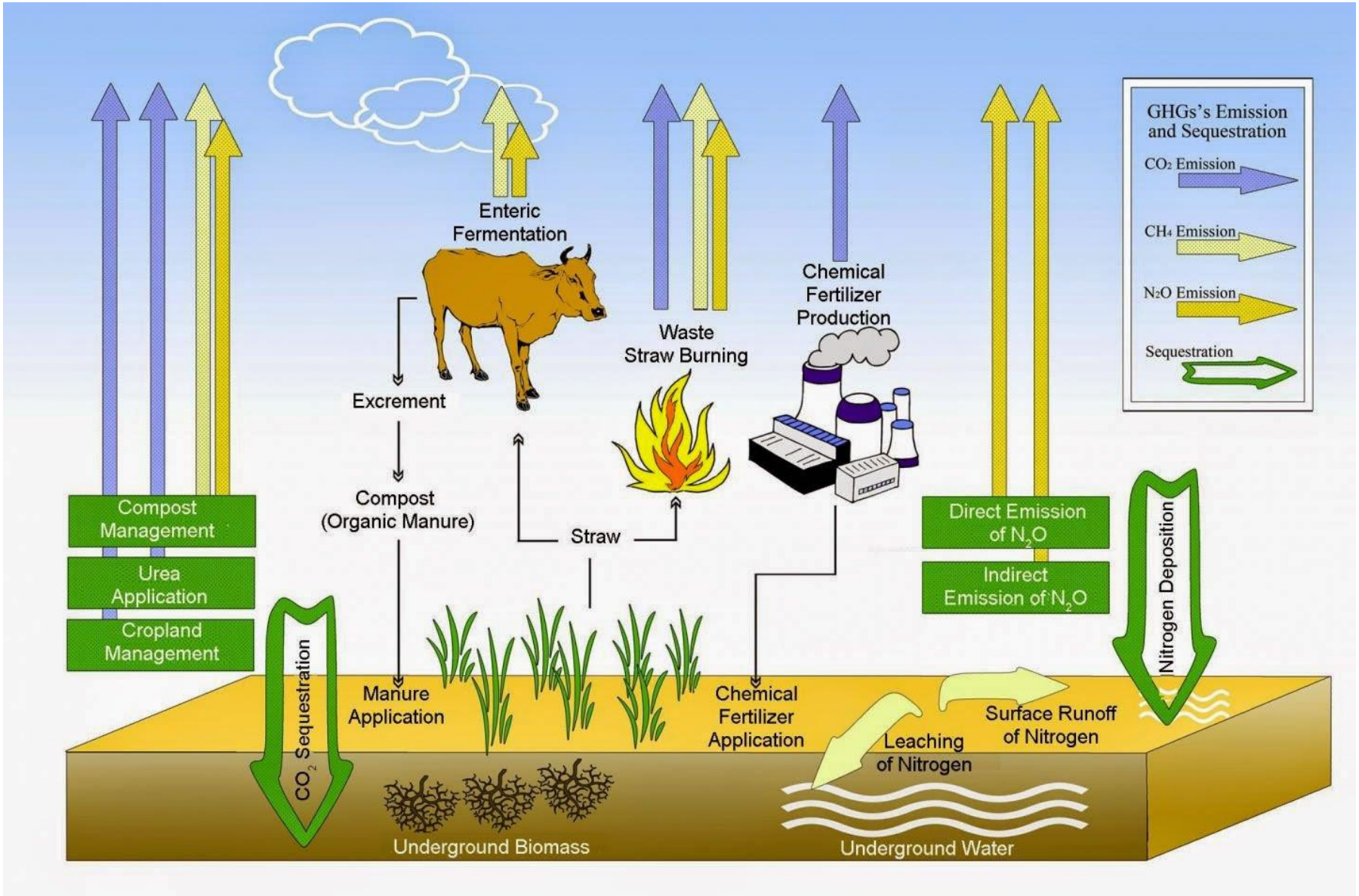
GHGs emission by sector



CO_2 Territorial Emission



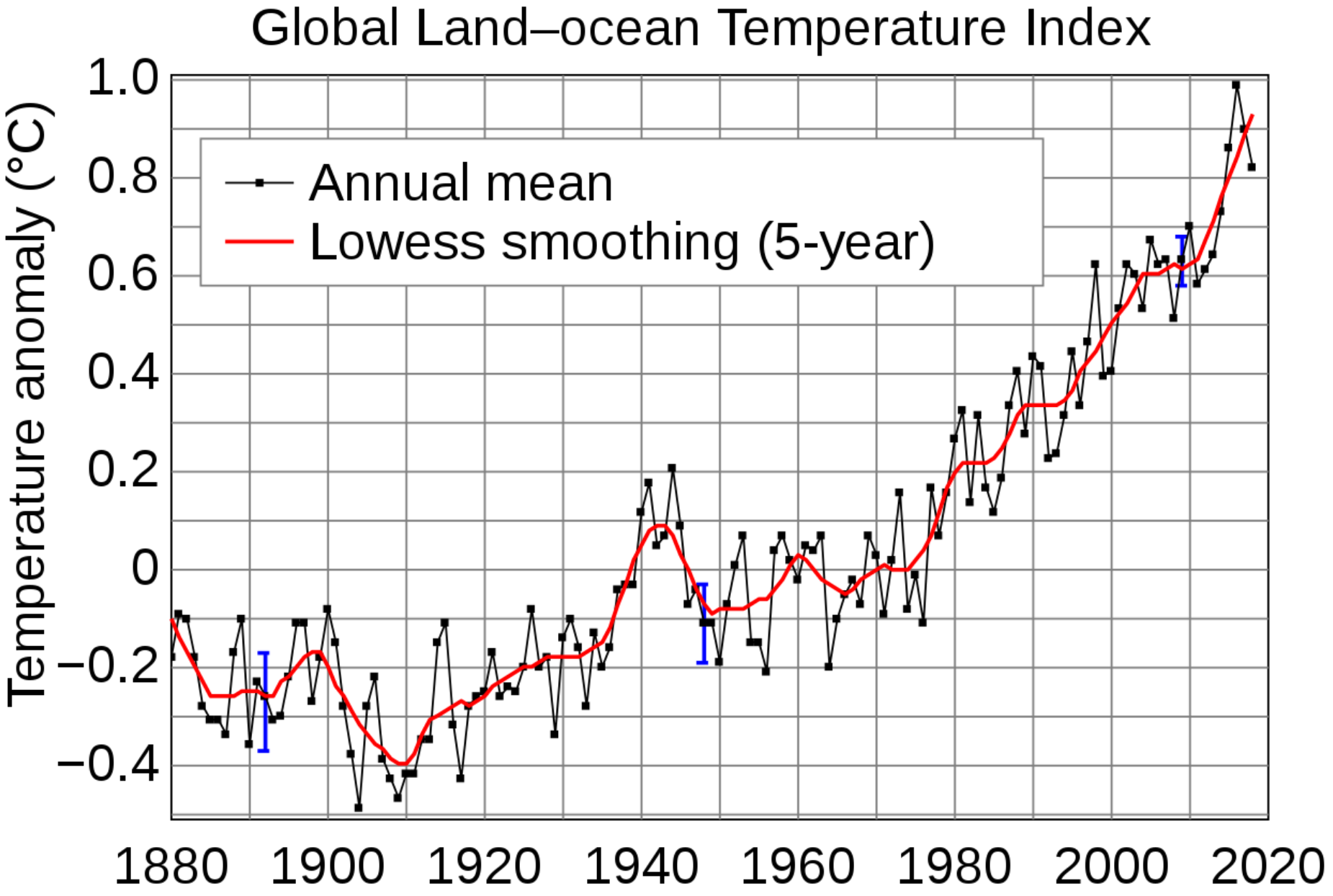
GHG emission and sequestration



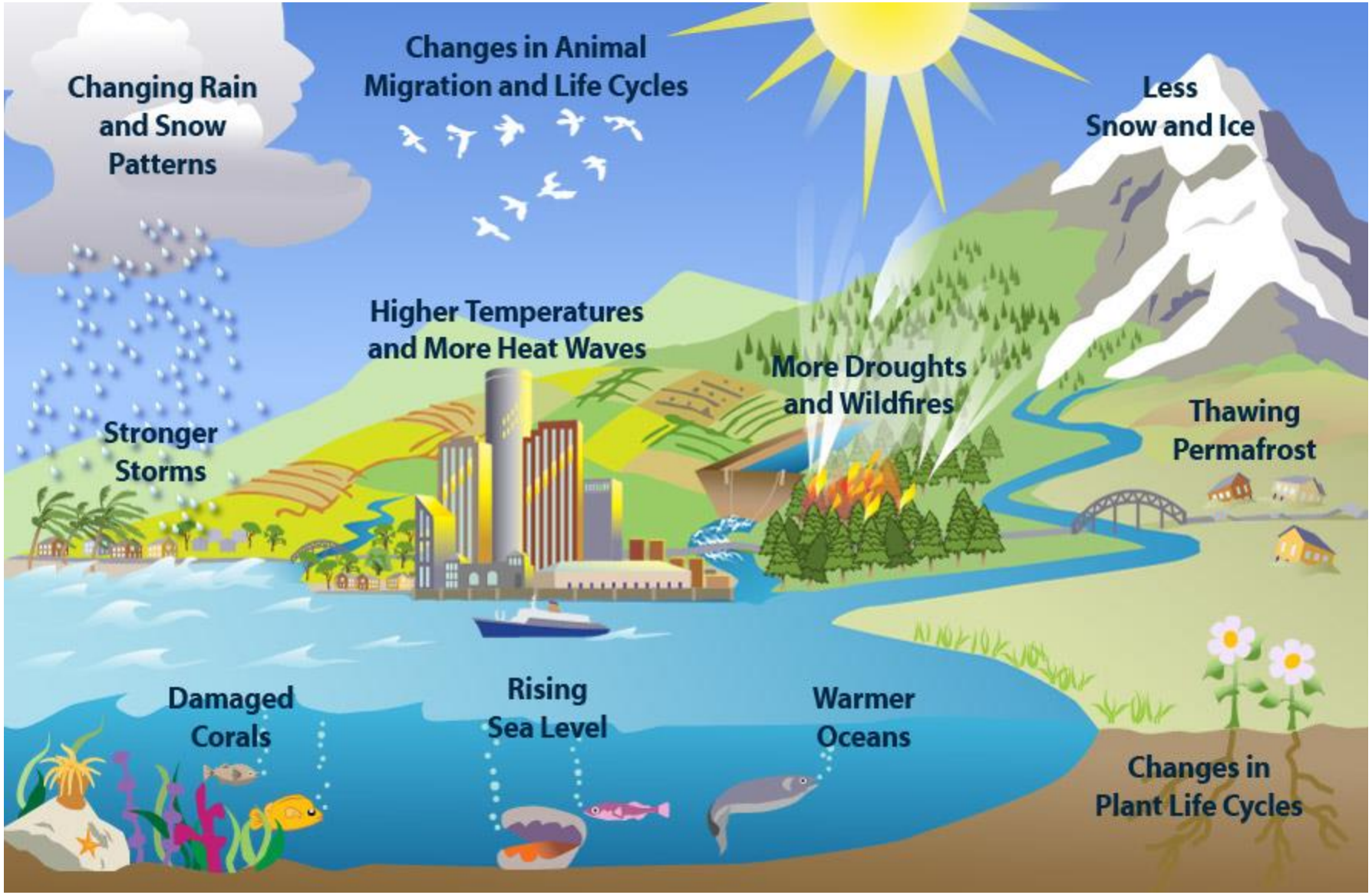
Effects

GLOBAL WARMING

Global mean temperatures are rising faster with time



Major effects of global warming



Temperature Increase

- Most of the increase occurred in the last few decades
- 1995-2006 were among the warmest on record
- The number of heat waves have increased
- A temperature increase of 0.2ºC is expected per decade if there is no control of emissions
- IPCC predicts that by 2100 temperature will rise 1.8-4ºC depending on the emission scenario

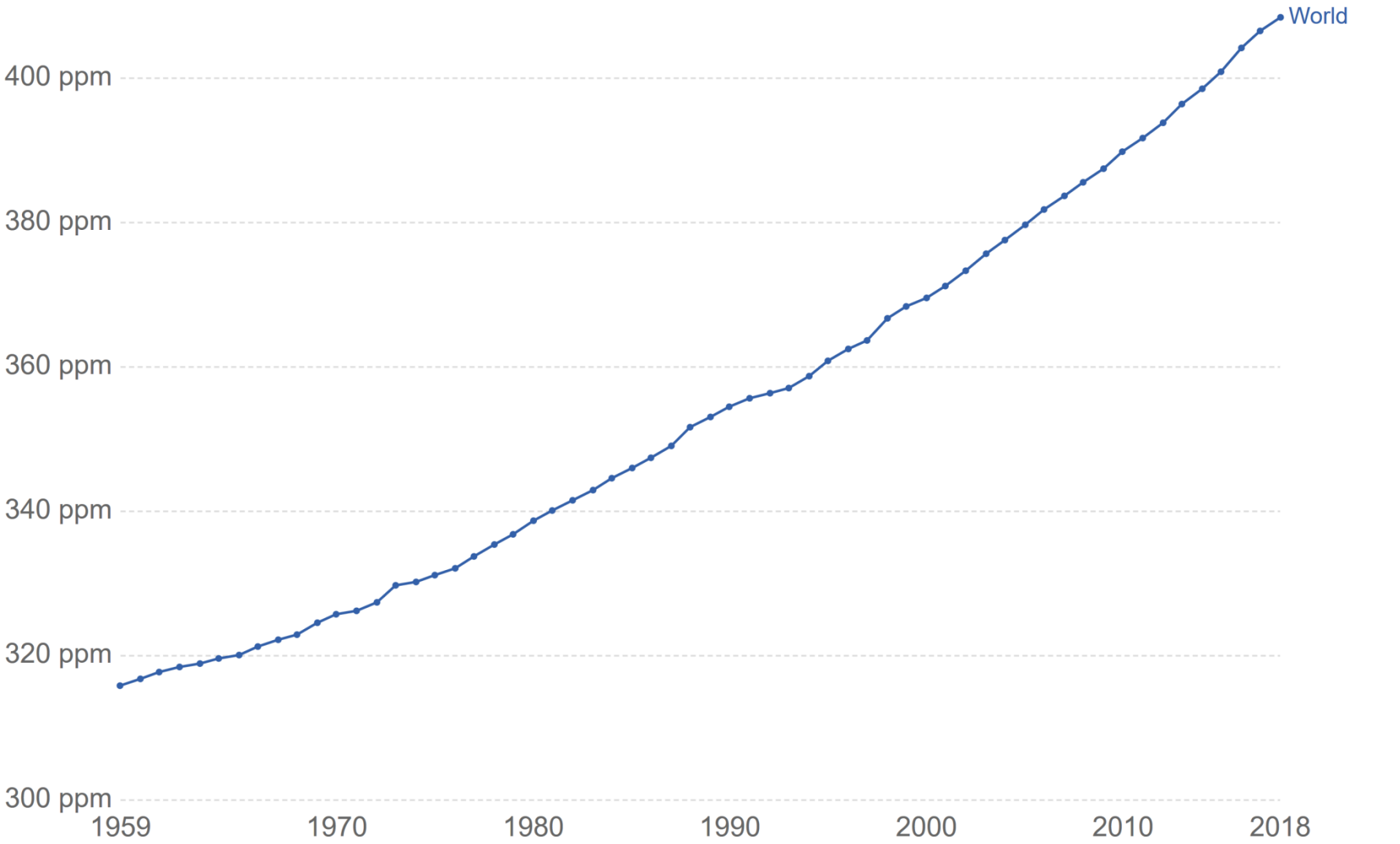
Definition of Global Warming

Global Warming is the slow and gradual warming of the lower layers of the atmosphere by the slowly increasing concentrations of **man-made greenhouse gases, primarily carbon dioxide.**

Global CO_2 atmospheric concentration

Global mean annual concentration of carbon dioxide (CO_2) measured in parts per million (ppm).

Our World in Data



Source: NOAA/ESRL (2018)

OurWorldInData.org/co2-and-other-greenhouse-gas-emissions/ • CC BY

Evidence of Global warming

- More warm days
- Melting of snow and ice
- Sea level rise (high confidence)
- Changes in precipitation patterns
- Carbon dioxide increasing in atmosphere
- More frequent extreme weather
- Disappearing Glaciers

Effects of Global Warming

Major effects

Rise in temperature

Rising Sea Level

Habitat Damage

Food and Water Supply

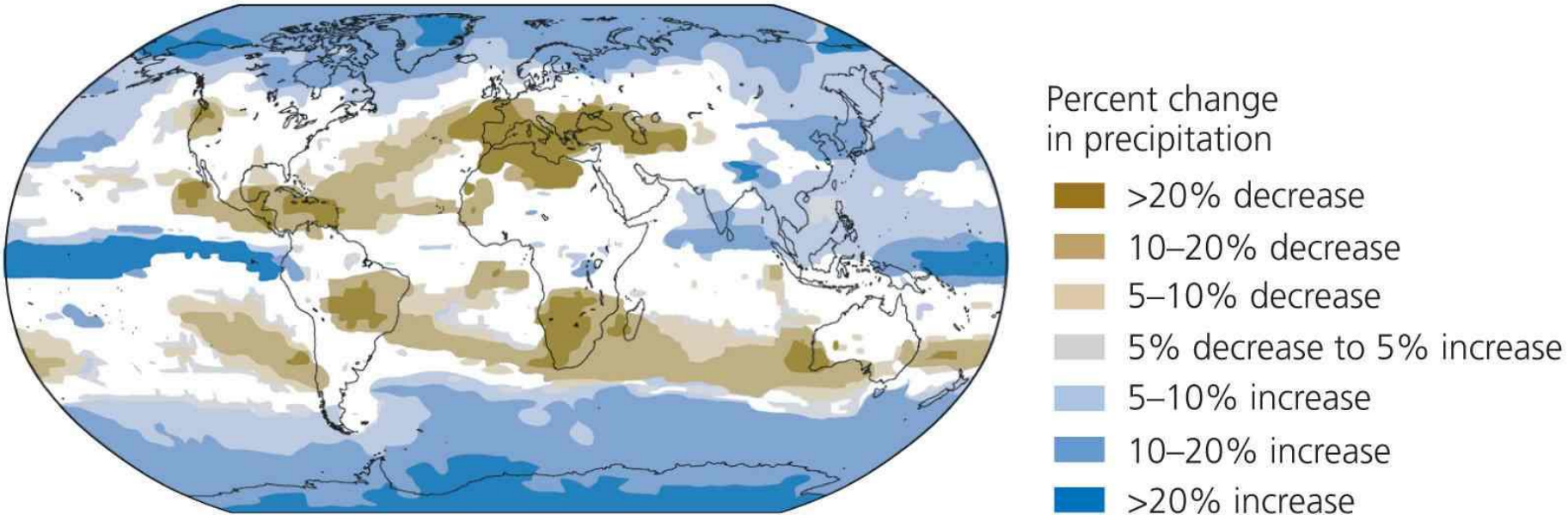
Increased temperature

- Models indicate that global average surface temperatures will rise by 1.5-4.5 ^{o}C over the next 100 years.

- Increases will be smallest at the equator and greatest at the poles

- Night temperatures have increased more than day temperatures

Changes in Precipitation



- It is predicted to increase at high latitudes and decrease at low and middle
- Will worsen water shortages near the tropics
- Away from the tropics heavy precipitation will become more frequent increasing chances of flooding
- Droughts will become more severe and frequent

Drought

Drought and high temperature episodes more often

– rice could be pushed out of some parts of Asia

– some semi-arid areas will become unable to support crop production

Storm

Melting Ice and Snow

- Risks of sudden floods
- Ice dams burst
- Reduction of summertime water supply
- Artic/Antarctic ice surface is decreasing
  - Resulting in larger darker ocean surfaces which capture heat and melt the ice faster
  - More dark surfaces on Earth reduces the *albedo* effect (light reflection)
  - As a result Earth's surface increases in temperature
  - Positive: new shipping lanes and possible sites for oil and gas exploration

Sea Level Rise

- Most models predict a sea level rise of about 50 cm by 2100
- This will lead to the loss of agricultural land due to flooding by sea water and salinization in areas that are newly coastal
- River deltas are some of the most productive agricultural lands

Problems with Rising Sea Levels

- Beach erosion
  - Florida, Washington, California, Texas, etc.

Flood

- Intrusion of salt water into aquifers
- Loss of wetlands (mangroves)
- Loss of coral reefs
  - Bangladesh, Maldives
- Possible evacuations and migration of people
  - Island nations of Maldives

Relationship of Climate Change with agriculture

Temperature Rise
-Increasing drought

→

-Crop failure
- Increasing fresh water demand

Precipitation change
-Increase in annual rainfall
- Occurrence of short duration heavy rainfall
-Rainfall at unexpected time

→

- Crop failure
-Erosion of soil
- Floods

Relationship of Climate Change with agriculture

Sea Level Rise
- Salinity intrusion
- River bank erosion
- Coastal erosion

→

- Decreasing fresh water supply
- Degradation of Agricultural land

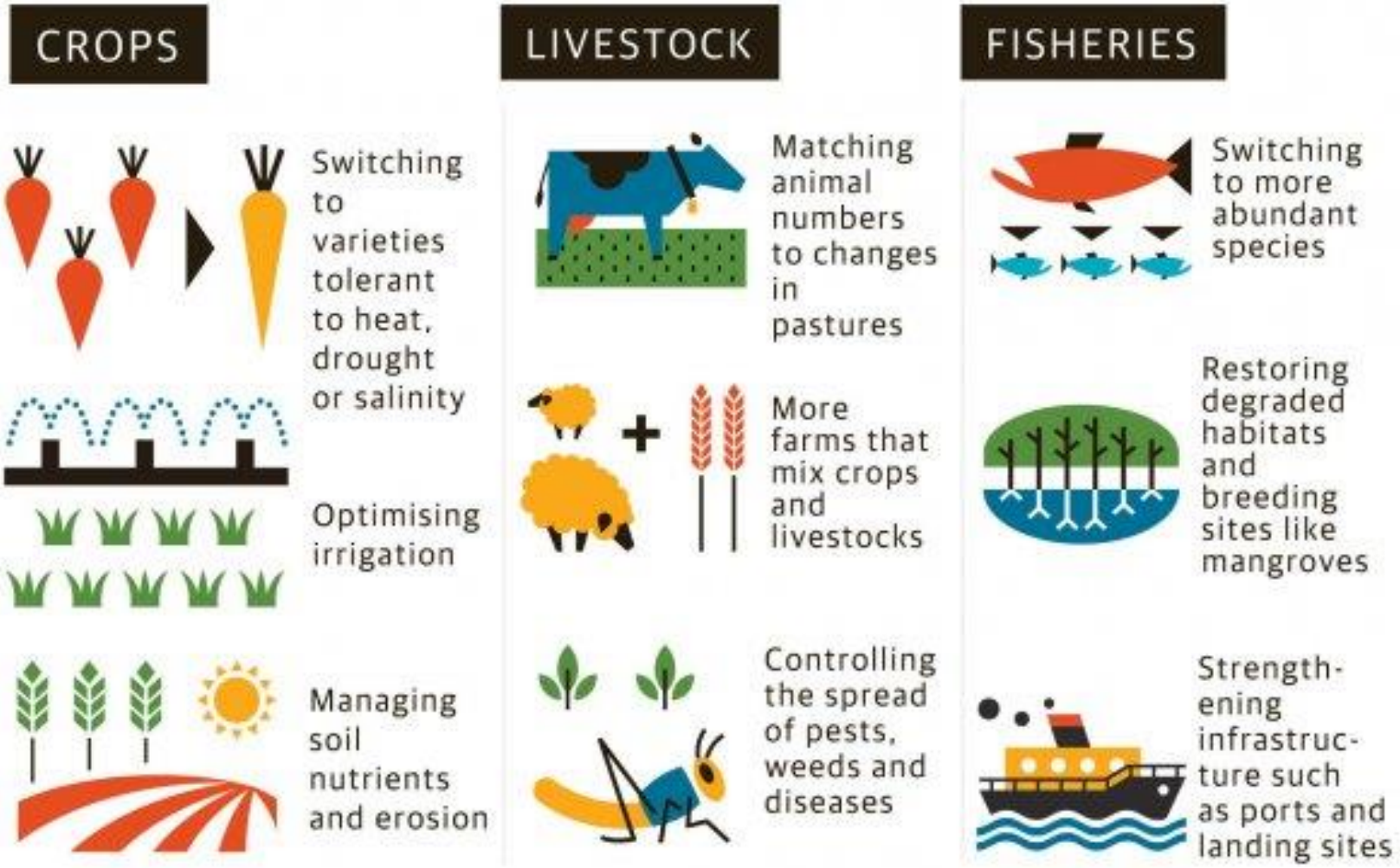
Mega Events
- Extreme temperatures

→

-Crop failure

Global crop yields are expected to be lower under 2°C of warming compared to 1.5°C, especially in sub-Saharan Africa, Southeast Asia, and Central and South America.

Climate change and farming: what you need to know about the IPCC report



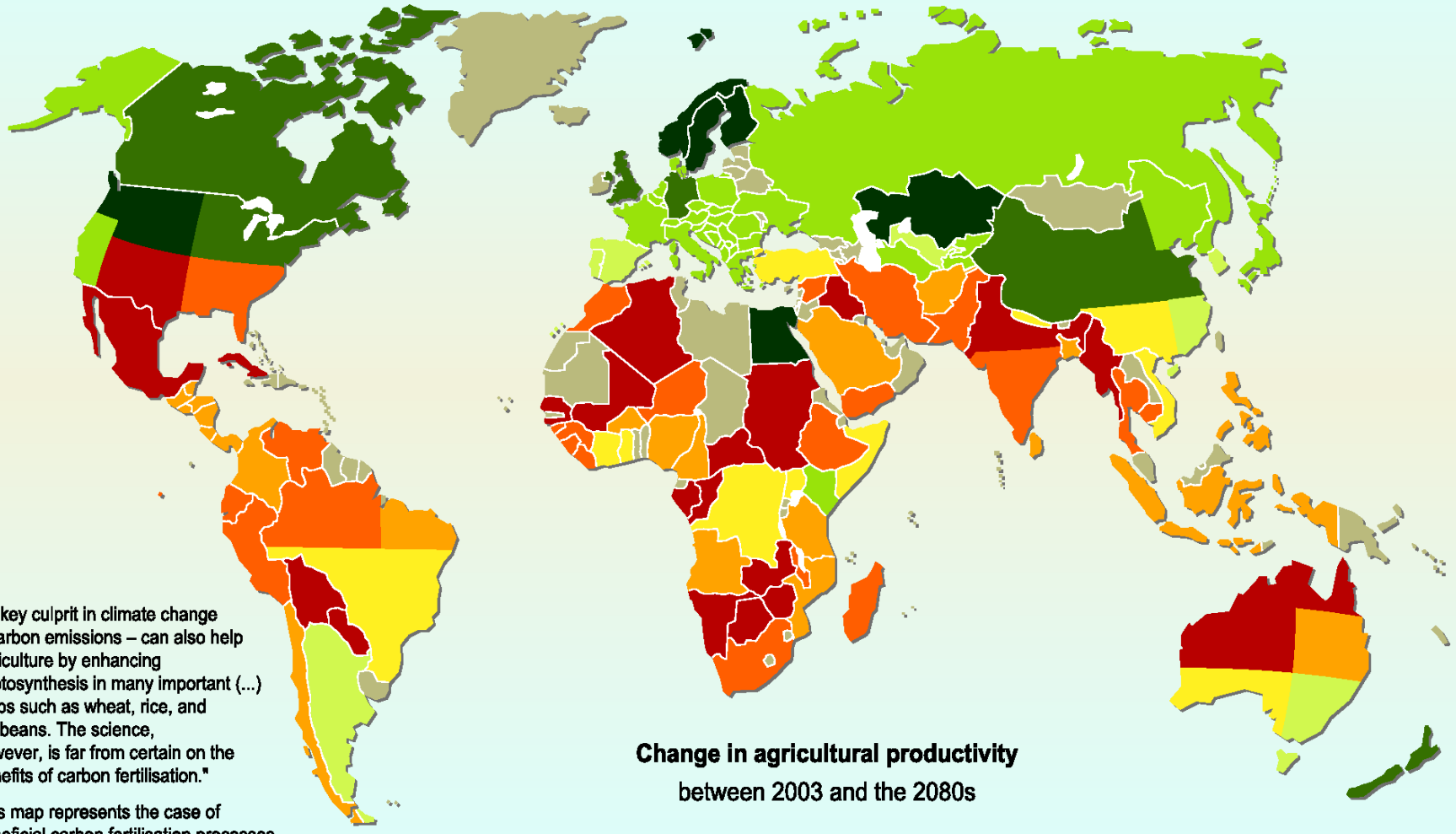
Agriculture Impacts

- General decrease in cereal crop yields in mid-latitudes
- Decreased crop yields in areas of increased drought
- Food prices increase relative to projections that exclude climate change
- Decreased cereal crop yields in most tropical and subtropical regions
- Increased heat stress in livestock and crop damage from heat waves
- Decreased frost damage for some crops

Water Resources Impacts

- Decreased water quantity and quality in some areas of increased drought
- Increased flood damage due to more intense precipitation events
- Decreased water supply in many water stressed countries (half-billion people in central Asia, southern Africa, and countries surrounding the Mediterranean affected)
- Increased water supply in some other water stressed countries (e.g. parts of Asia)

Projected impact of climate change on agricultural yields



" A key culprit in climate change – carbon emissions – can also help agriculture by enhancing photosynthesis in many important (...) crops such as wheat, rice, and soybeans. The science, however, is far from certain on the benefits of carbon fertilisation."

This map represents the case of beneficial carbon fertilisation processes.

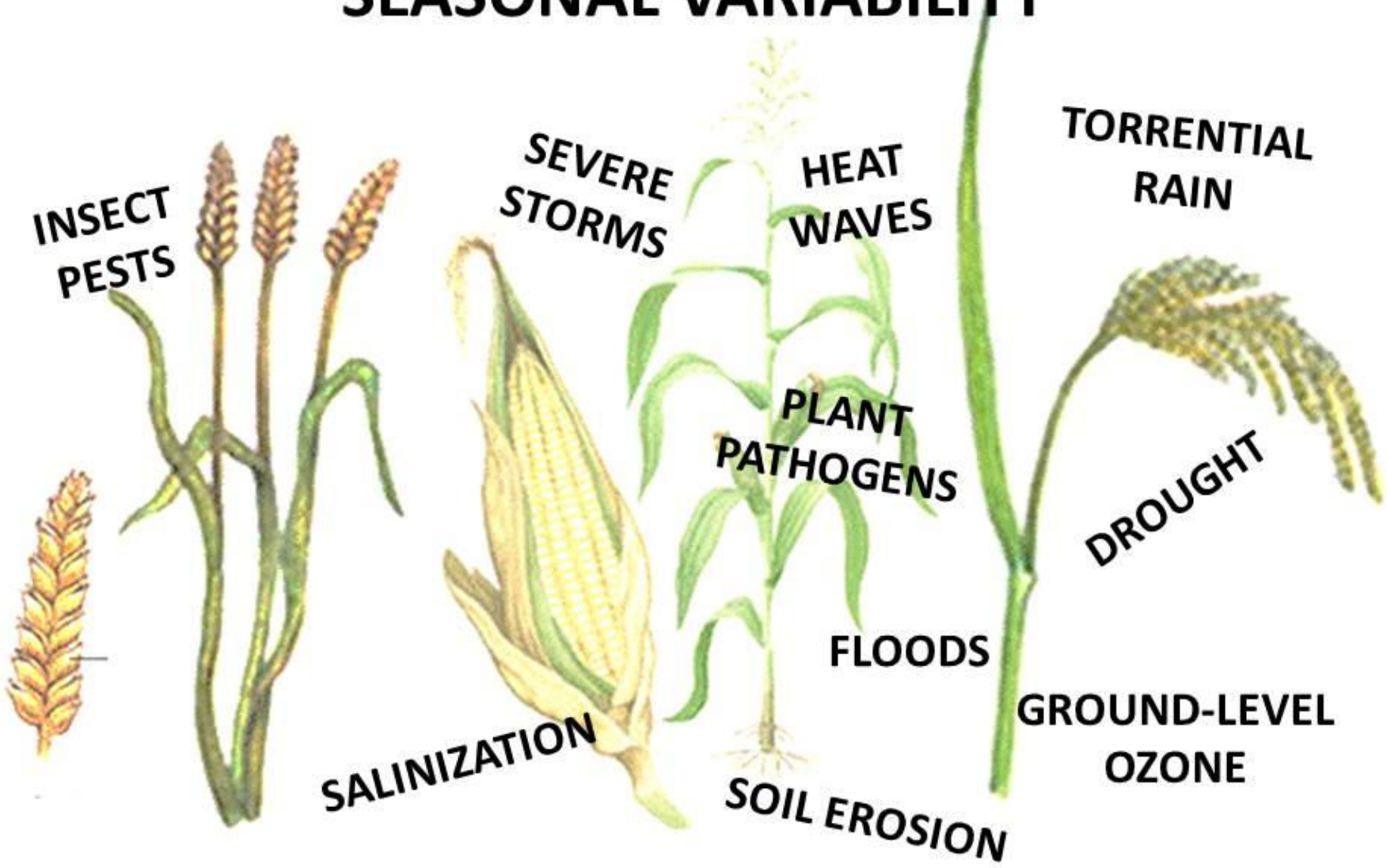
Source: Cline W., 2007, *Global Warming and Agriculture*.

Changes in Crop Quality

- In general, the higher levels of carbon (CO_2) will lead to crops (seeds or, in the case of forages, leaves and stems) that are higher in carbon and lower in protein.

- On the other hand, material with higher sugar contents will make better silage.

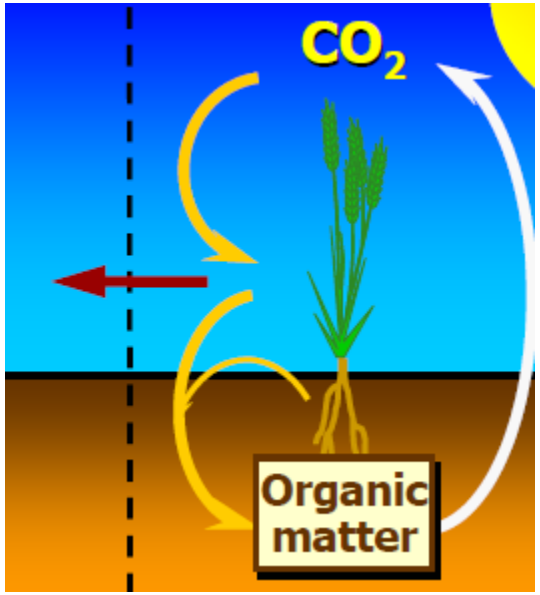
SEASONAL VARIABILITY



Changes in Soil Organic Matter

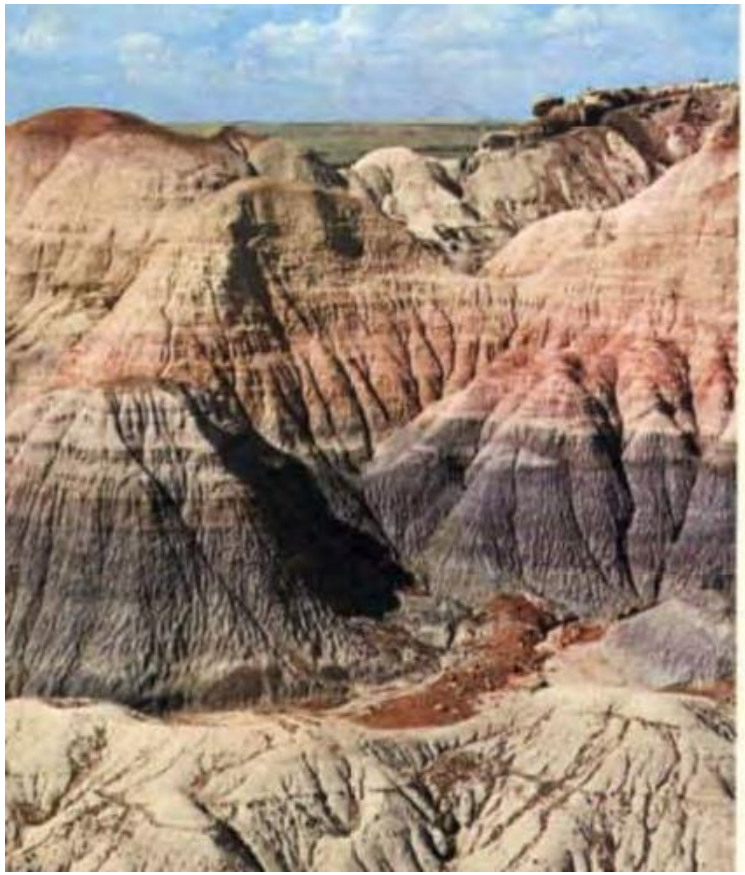
- Higher temperatures and, higher rainfall leavels, will accelerate soil organic matter break down

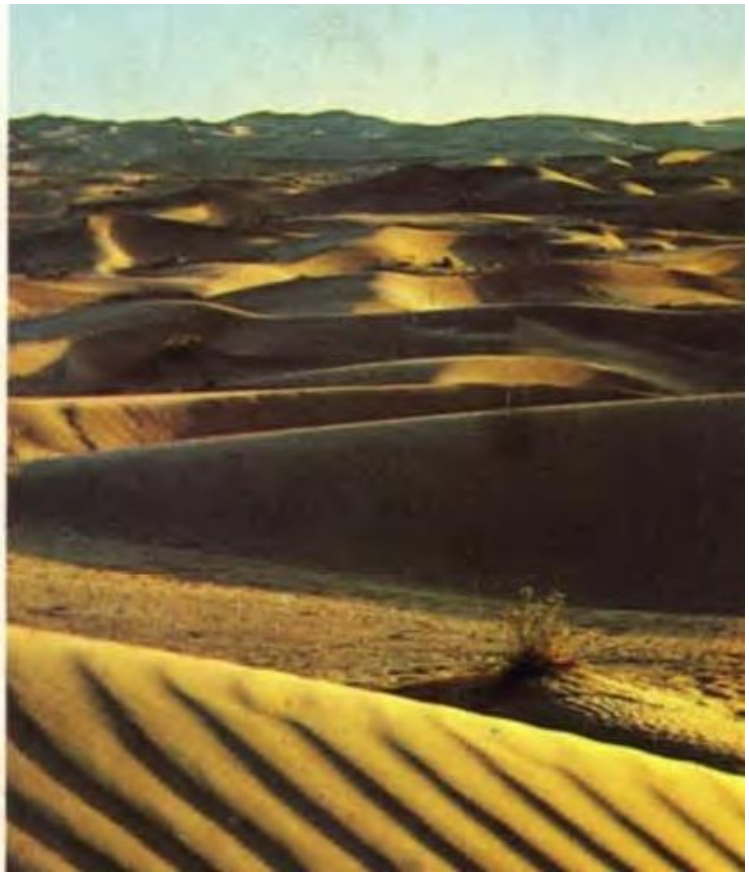
- Low organic matter soils hold few nutrients and are more susceptible to drought



Soil Erosion

- In many areas soils will be drier
- Increased equator-to-pole heat flux will mean greater average wind speeds





Changes of Grassland Species

- Where dry hot areas become more so there will be a shift from C_3 to C_4 species
- In temperate-moist areas increasing CO_2 will favor C_3 over C_4 species.

Consequences for Poultry and Fish

- Changes in temperature and precipitation could cut breeding populations of ducks and other poultries.
- Cold water fish habitat may be reduced and lost
- Migration/breeding cycles may be disrupted for species that depend on temperature signals

Consequences for Livestock production

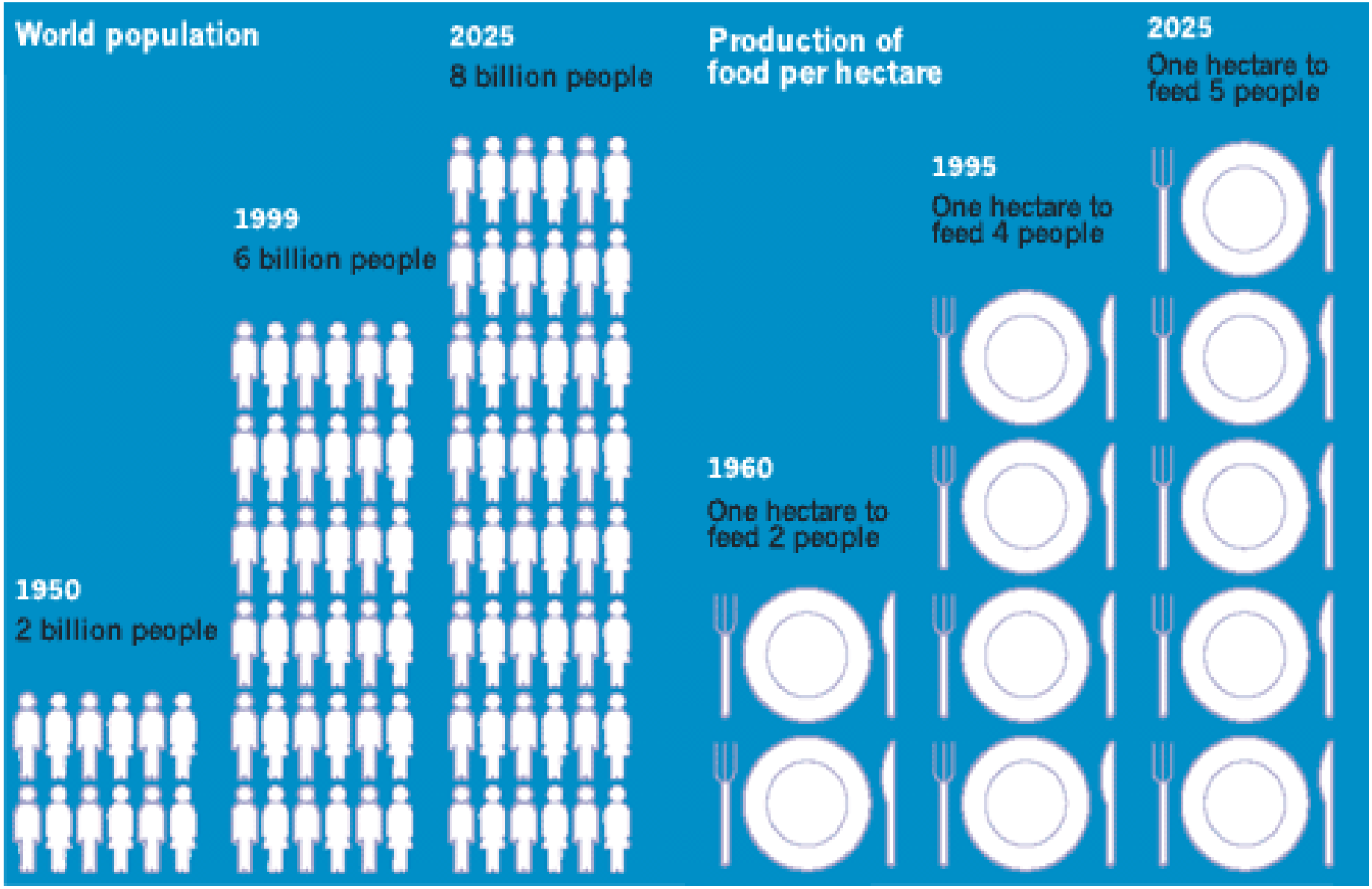
- Changes in temperature decrease the forage production.
- Heat stress for livestock
- Habitat for livestock will be declined

Estimates...

- Most models show a decreases in world food production due to climate change.

- Tropical developing countries, those most directly dependent on agriculture, will suffer from 10–20% decrease in crop production.

Challenges for Plant Scientists



Human Health impacts

- Expansion of the areas of potential transmission of malaria and dengue fever (medium-to-high confidence); roughly 300 million more people at risk of malaria
- Increased heat-related deaths and illness, affecting particularly the elderly, sick, and those without access to air conditioning
- Increased risks to human life, risk of infectious disease epidemics and many other health risks where floods, droughts or storms increase in frequency and/or intensity
- Decreased winter deaths in some temperate regions

Ecosystem Impacts

- Coral death from exposure to 3-4 ºC higher seasonal maximum sea-surface temperatures for 6 months or more
- Extensive reduction in Arctic summer sea-ice extent with benefits for shipping but adverse effects on sea-ice dependent animals (e.g. polar bears, seals, walrus)
- Coastal wetland loss from sea level rise (up to 10% globally for 20 cm rise, higher percentages in some areas)
- Increased disturbances of ecosystems by fire and insect pests
- Increase net primary productivity of many mid- and high-latitude forests
- Extinction of some critically-endangered and endangered species

Predicted effects of climate change on agriculture over the next 50 years

Climatic element	Expected changes by 2050's	Confidence in prediction	Effects on agriculture
CO_2	Increase from 360 ppm to 450 - 600 ppm (2005 levels now at 379 ppm)	Very high	Good for crops: increased photosynthesis; reduced water use
Sea level rise	Rise by 10 -15 cm Increased in south and offset in north by natural subsistence/rebound	Very high	Loss of land, coastal erosion, flooding, salinisation of groundwater
Temperature	Rise by 1-2^{o}C. Winters warming more than summers. Increased frequency of heat waves	High	Faster, shorter, earlier growing seasons, range moving north and to higher altitudes, heat stress risk, increased evapotranspiration
Precipitation	Seasonal changes by ± 10%	Low	Impacts on drought risk' soil workability, water logging irrigation supply, transpiration
Storminess	Increased wind speeds, especially in north. More intense rainfall events.	Very low	Lodging, soil erosion, reduced infiltration of rainfall
Variability	Increases across most climatic variables. Predictions uncertain	Very low	Changing risk of damaging events (heat waves, frost, droughts floods) which effect crops and timing of farm operations

Potential positive effects

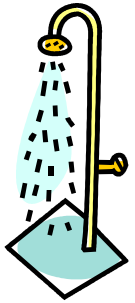
- Higher temperatures and higher CO_2 concentrations is improving ecosystems productivity
- Increase photosynthesis for some crop plants
- Melting of Arctic ice is opening the Northwest Passage in summer
- Increase in temperature due to global warming, is favorable condition for algae
- Rise in the dense forestation
- Formation of oil reserves

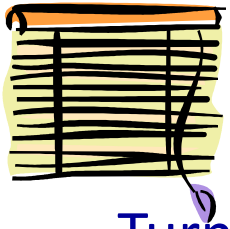
SOLUTIONS

At personal level

Turn off your computer or the TV when you're not using it.

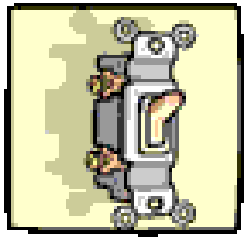
Take shorter showers. Heating water uses energy.



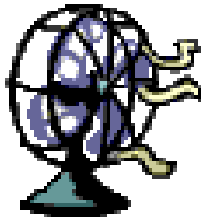


Keep rooms cool by closing the blinds, shades, or curtains.

Turn off the lights when you leave a room.

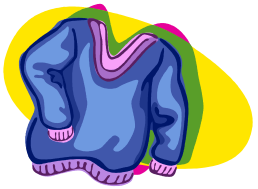


Use compact fluorescent bulbs.



Dress lightly when it's hot instead of turning off the air conditioner or use a fan.

Dress warmly when it's cold instead of turning up the heat.



Offer to help your parents keep the air filters on your AC and furnace clean.

Walk short distances instead of asking for a ride in the car.

Plant a tree

Recycle.

At National and International level

- International agreement to fight global warming, although signatories are committed to reduce green house gas emission.

- Halt Deforestation and Soil Erosion.

- Scientists can separate species of plants with a preferred quality in plant hardiness, such as drought resistance or higher fruit production.