7.7 EFFECTS OF CLIMATE CHANGE ON HUMAN SOCIETY AND OUR RESPONSE

College Board Topic 9.4 and 7.6

Related Reading: Chapter 18, especially pages 492 - 515

Learning Objectives and Essential Knowledge

ENDURING UNDERSTANDING

STB-4

Local and regional human activities can have impacts at the global level.

LEARNING OBJECTIVE

STB-4.E

Identify the threats to human health and the environment posed by an increase in greenhouse gases.

ESSENTIAL KNOWLEDGE

STB-4.E.1

Global climate change, caused by excess greenhouse gases in the atmosphere, can lead to a variety of environmental problems including rising sea levels resulting from melting ice sheets and ocean water expansion, and disease vectors spreading from the tropics toward the poles. These problems can lead to changes in population dynamics and population movements in response.

SUGGESTED SKILL

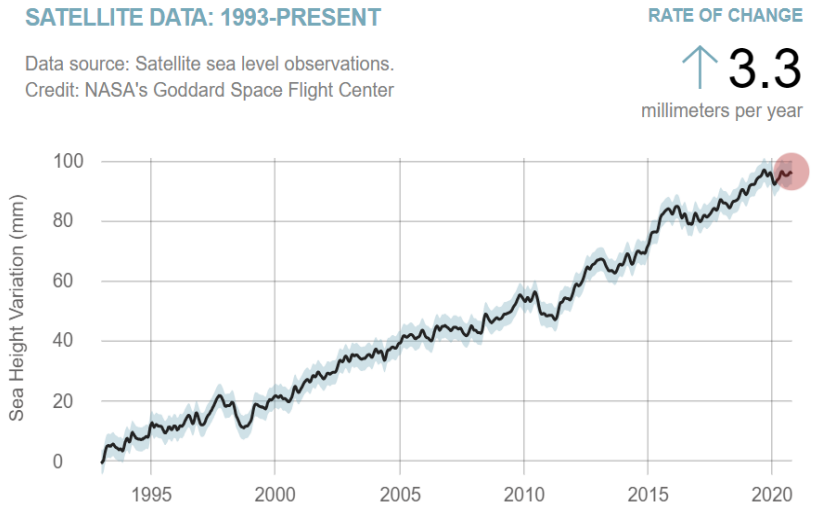
Visual Representations

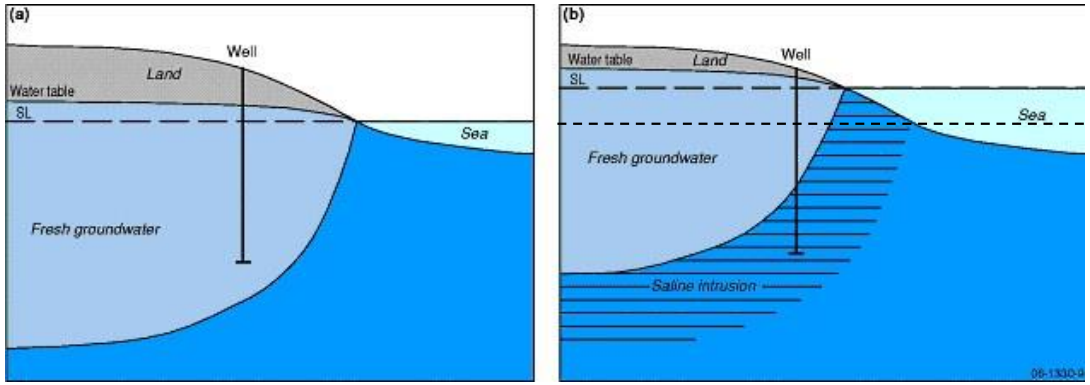
2.C

Explain how environmental concepts and processes represented visually relate to broader environmental issues.

Impact of sea level rise on human society

- Sea Level rise is expected to increase between 10" to 30" by 2100 based on a projected temperature increases of 1.5℃
  - If all the worlds glaciers and ice sheets melted, sea level would rise 216 feet.
- Increased coastal flooding and beach erosion will lead to a real estate damage and loss.
  - Loss of salt marshes, barrier islands, coral reefs, and mangroves from rising sea levels, results in less protection of coastlines from storm surge.
  - Coastal communities face increased storm surge due to stronger storms and higher winds.
  - Increased repair costs, increased insurance costs, costs of property loss.
- Salt water intrusion into coastal freshwater aquifers
- Increased costs of building sea wall and installing pumps to mitigate rising sea levels in low lying cities such Miami and Jakarta

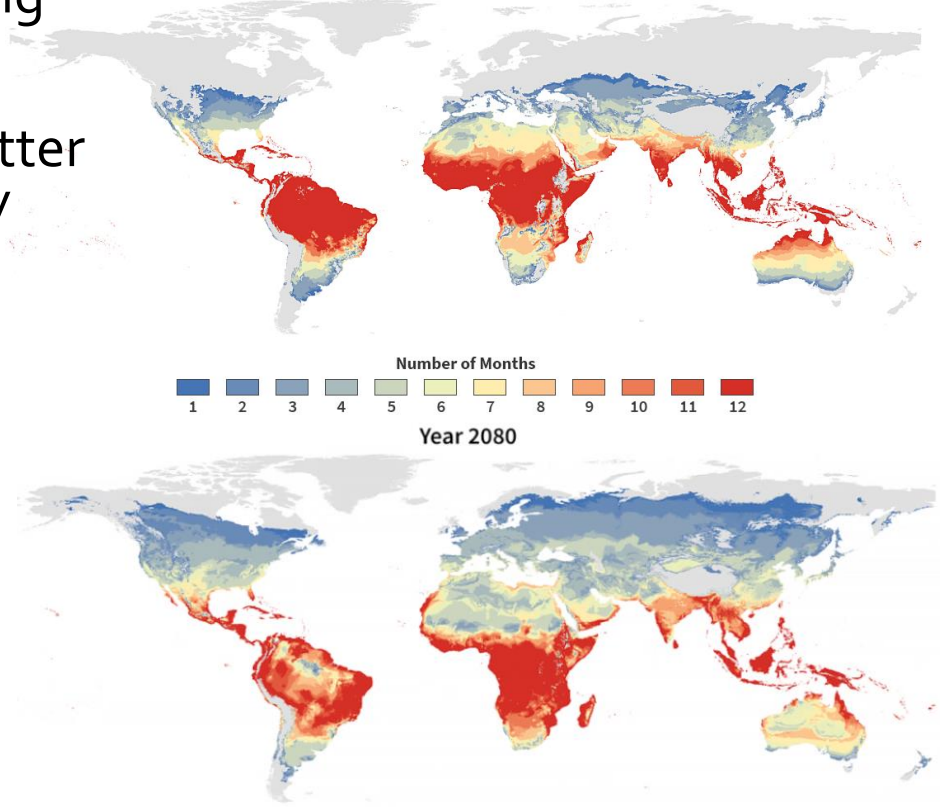




Climate change and human health

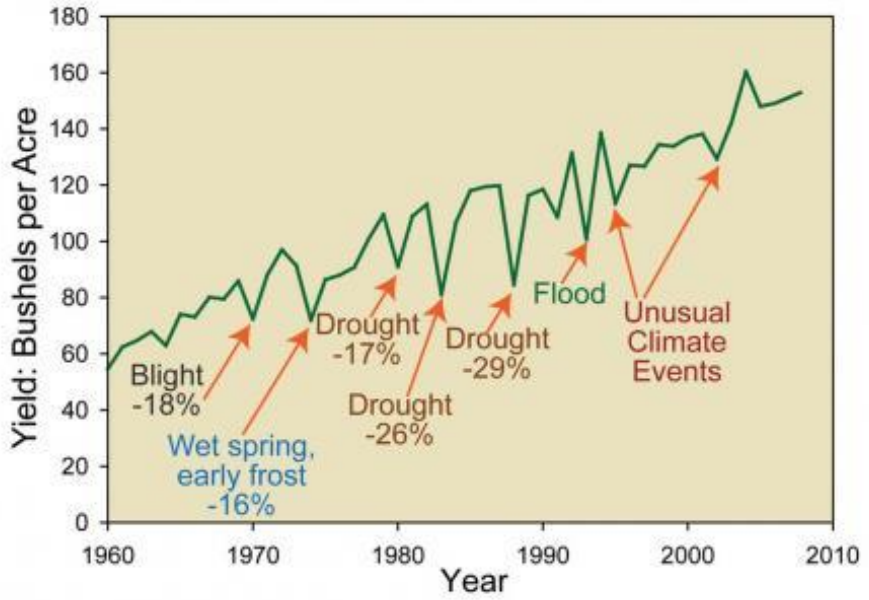
- Climate determines the population distribution of disease ***vectors*** (fleas, ticks, mosquitos) and the ***pathogens*** they spread (Zika, west nile, dengue fever, malaria, Lyme)
  - Warmer winters increase populations of mosquitos, fleas, and ticks; increasing human exposure to the diseases they carry.
  - Wet conditions increase mosquito populations by increasing suitable breeding sites.
- Pathogens causing waterborne illnesses (cholera) survive better in warmer waters making chances of their spread more likely
  - Flooding from severe weather can overwhelm water treatment facilities and cause sewage treatment plants to overflow into surrounding surface waters
  - Increased runoff into surface increases viral and bacterial infections for recreational users (surfers)
- Injury and illness caused by natural disasters (fire, flood, hurricanes, extreme heat) are likely to increase
  - Heat stress (heat exhaustion, heat stroke, cardiovascular stress, kidney disorders).
  - Made worse by urban heat islands and elderly populations.

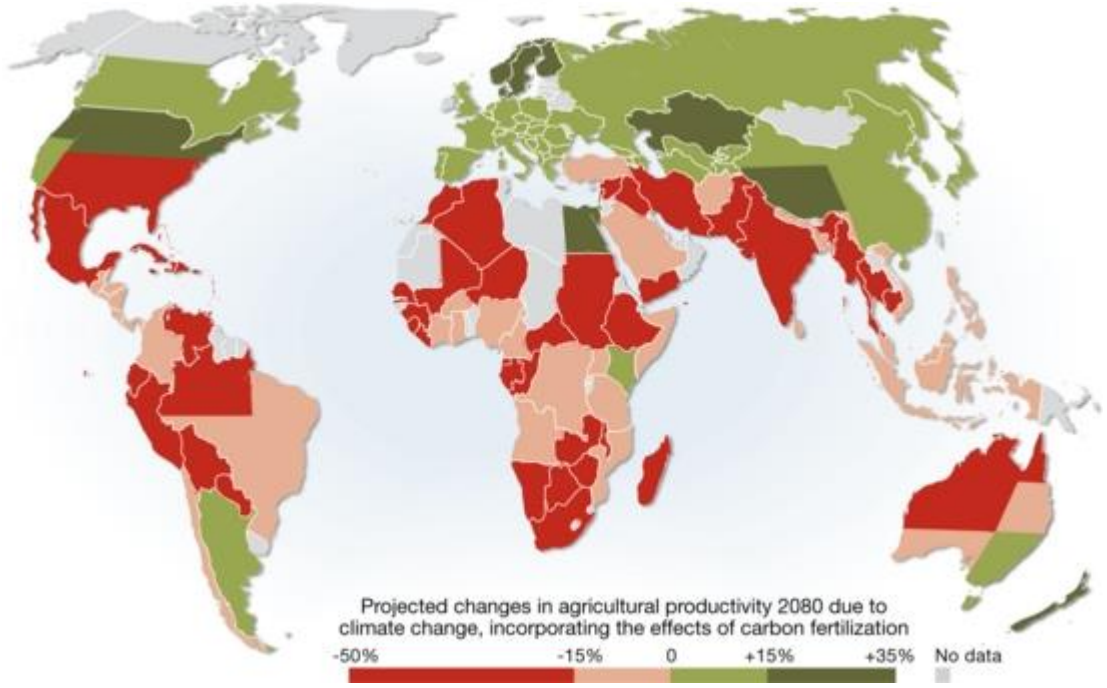
Current and Projected Distribution of Aedes aegypti
(vector for dengue fever, yellow fever, and Zika viruses)



Climate change and food production

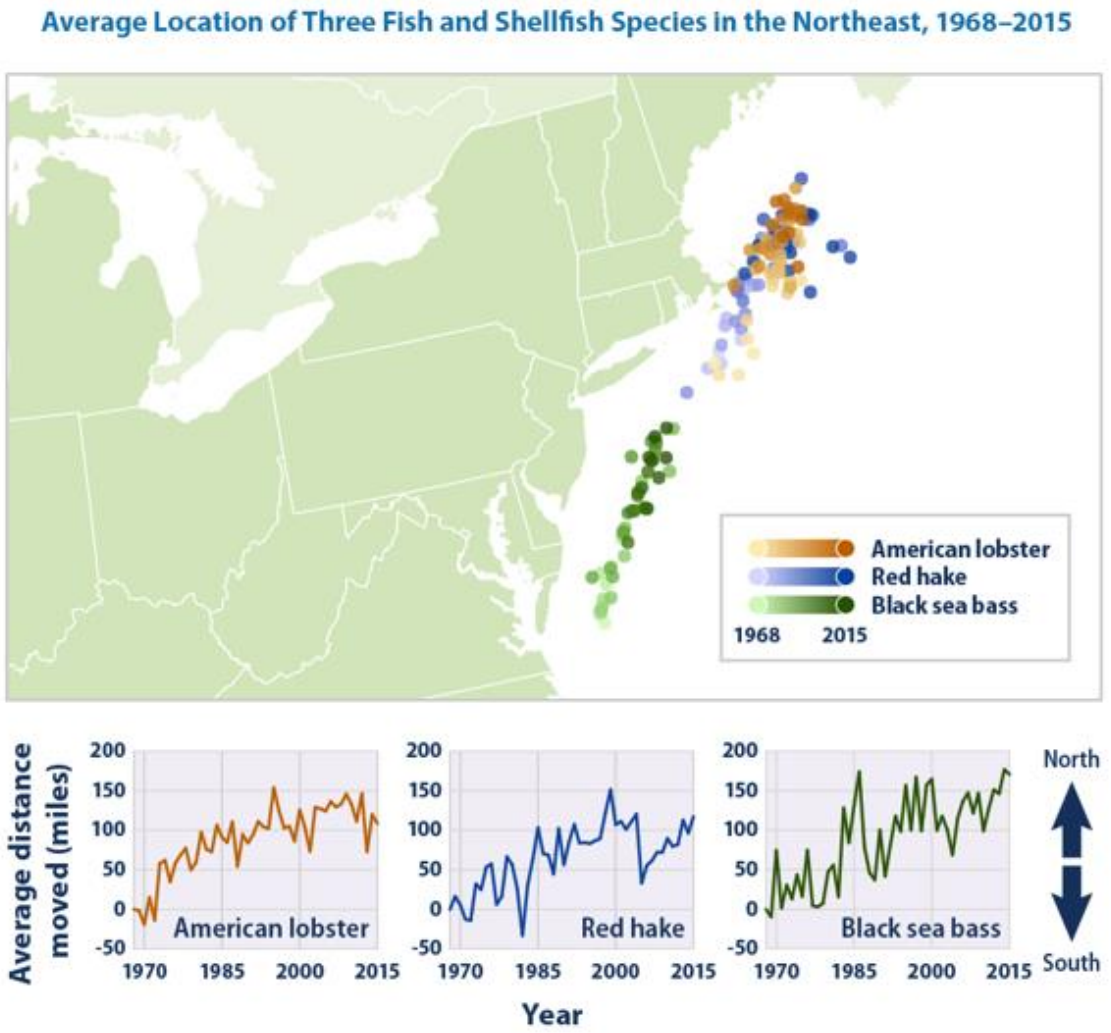
- Extended growing seasons and increased CO2 may increase productivity in some regions.
- Challenges of climate change facing agriculture include:
  - Increased frequency and intensity of severe weather events (floods/freezes/hail/droughts) which damage crops and accelerates soil degradation.
  - Rising CO_2 levels increase growth rates, but decrease nutritional quality of crops (lower concentrations of proteins and minerals).
  - Many weeds, insects, and fungi thrive under warmer conditions.
    - Increases pesticide use and results in increased pesticide resistance.
- As climate changes in response to global warming, agricultural regions may also shift.
  - Depends on crop species range of tolerance, as well as the soil quality and water availability in surrounding areas.

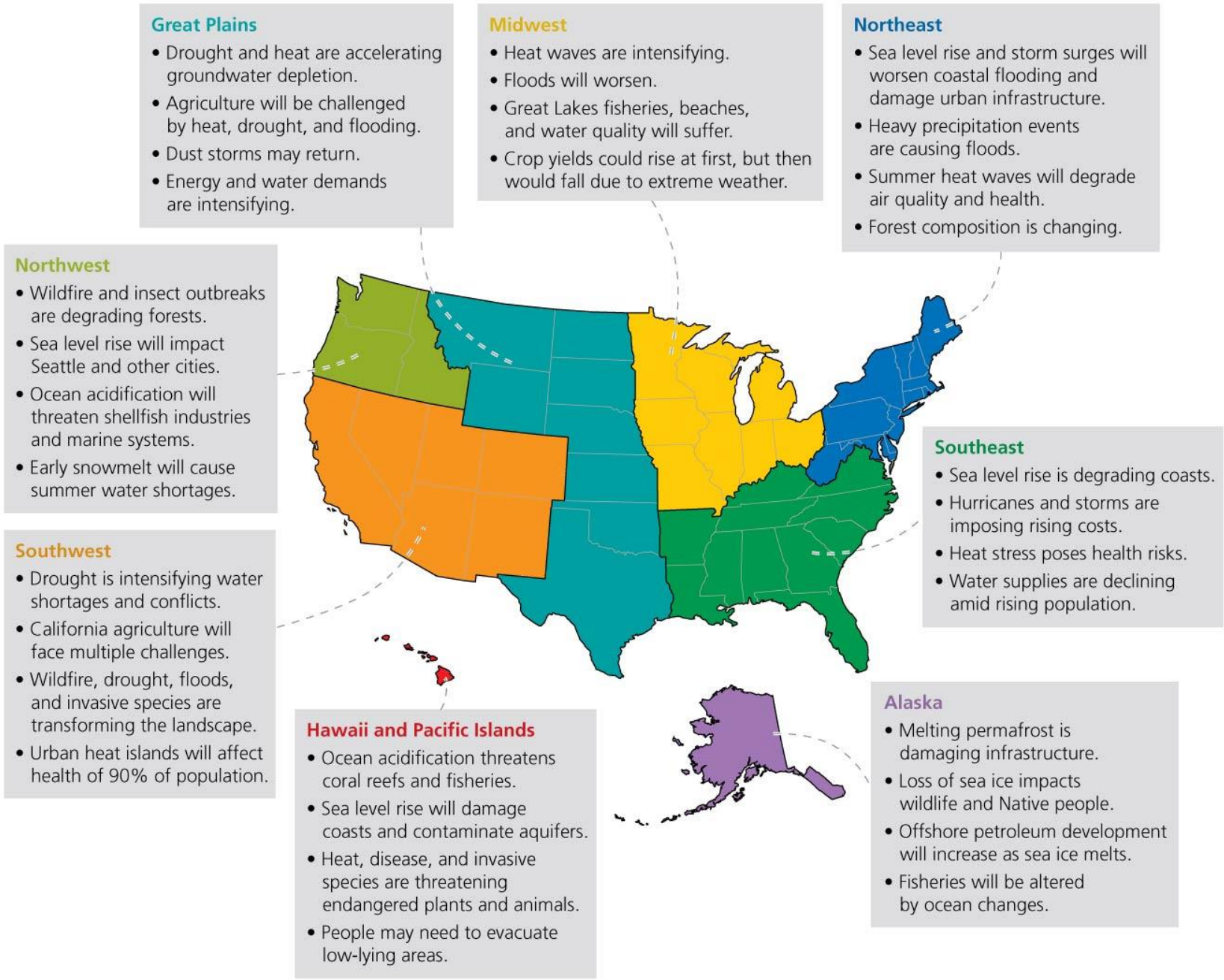




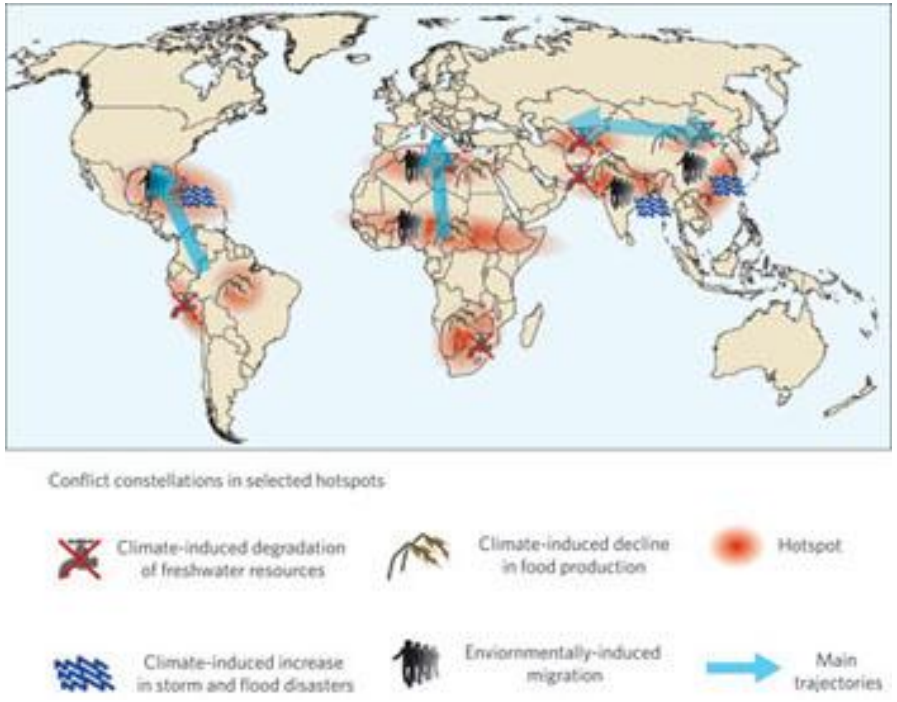
Climate change and food production

- Climate change impacts on livestock production.
  - Drought reduces the quantity of forage for livestock.
  - Increased CO_2 levels may reduce quality of forage too.
  - Livestock populations are also affected by heat stress.
  - Livestock pathogens are also expanding their range as climate warms resulting in increased use of antibiotics and antibiotic resistance.
- Warmer waters will likely cause the habitat ranges of many fish and shellfish species to shift.
  - The timing of mating and migrations among some aquatic species will also be altered.
  - Rising CO2 levels, result in ocean acidification which dissolves the $CaCO_3$ shells of shellfish.




Great Plains
• Drought and heat are accelerating groundwater depletion.
• Agriculture will be challenged by heat, drought, and flooding.
• Dust storms may return.
• Energy and water demands are intensifying.
Midwest
• Heat waves are intensifying.
• Floods will worsen.
• Great Lakes fisheries, beaches, and water quality will suffer.
• Crop yields could rise at first, but then would fall due to extreme weather.
Northeast
• Sea level rise and storm surges will worsen coastal flooding and damage urban infrastructure.
• Heavy precipitation events are causing floods.
• Summer heat waves will degrade air quality and health.
• Forest composition is changing.
Northwest
• Wildfire and insect outbreaks are degrading forests.
• Sea level rise will impact Seattle and other cities.
• Ocean acidification will threaten shellfish industries and marine systems.
• Early snowmelt will cause summer water shortages.
Southeast
• Sea level rise is degrading coasts.
• Hurricanes and storms are imposing rising costs.
• Heat stress poses health risks.
• Water supplies are declining amid rising population.
Southwest
• Drought is intensifying water shortages and conflicts.
• California agriculture will face multiple challenges.
• Wildfire, drought, floods, and invasive species are transforming the landscape.
• Urban heat islands will affect health of 90% of population.
Hawaii and Pacific Islands
• Ocean acidification threatens coral reefs and fisheries.
• Sea level rise will damage coasts and contaminate aquifers.
• Heat, disease, and invasive species are threatening endangered plants and animals.
• People may need to evacuate low-lying areas.
Alaska
• Melting permafrost is damaging infrastructure.
• Loss of sea ice impacts wildlife and Native people.
• Offshore petroleum development will increase as sea ice melts.
• Fisheries will be altered by ocean changes.

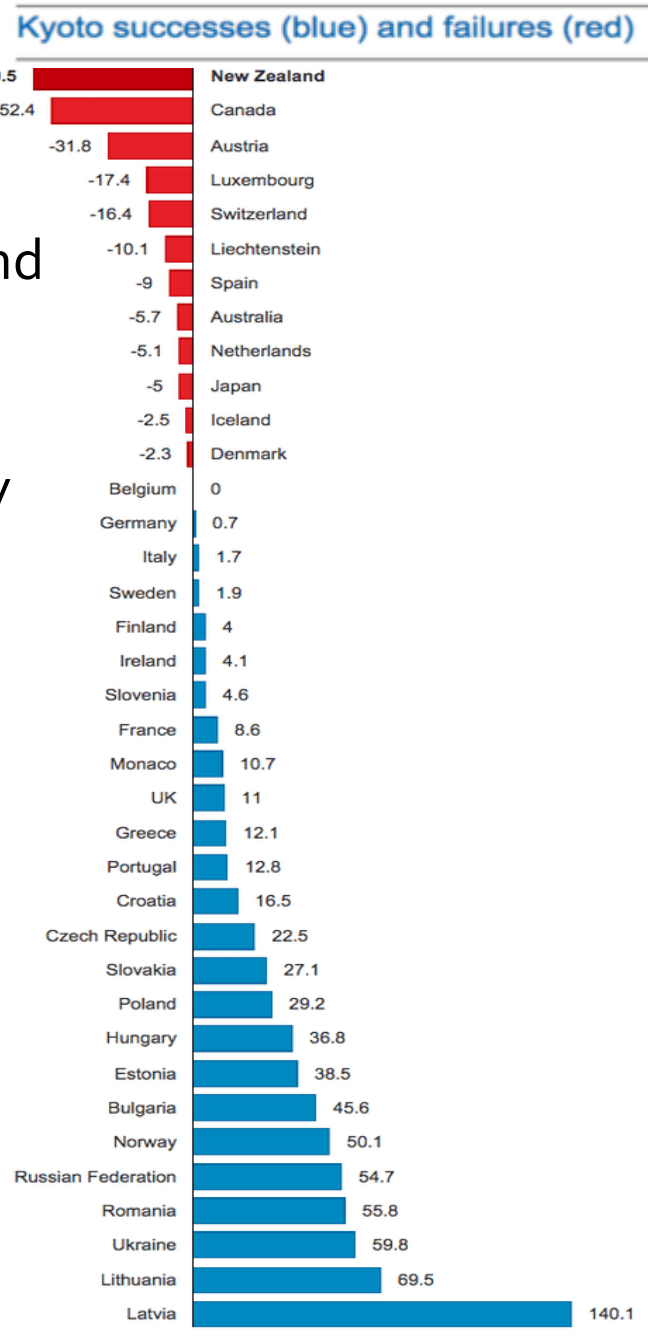
Human migrations are already occurring as a result of climate change



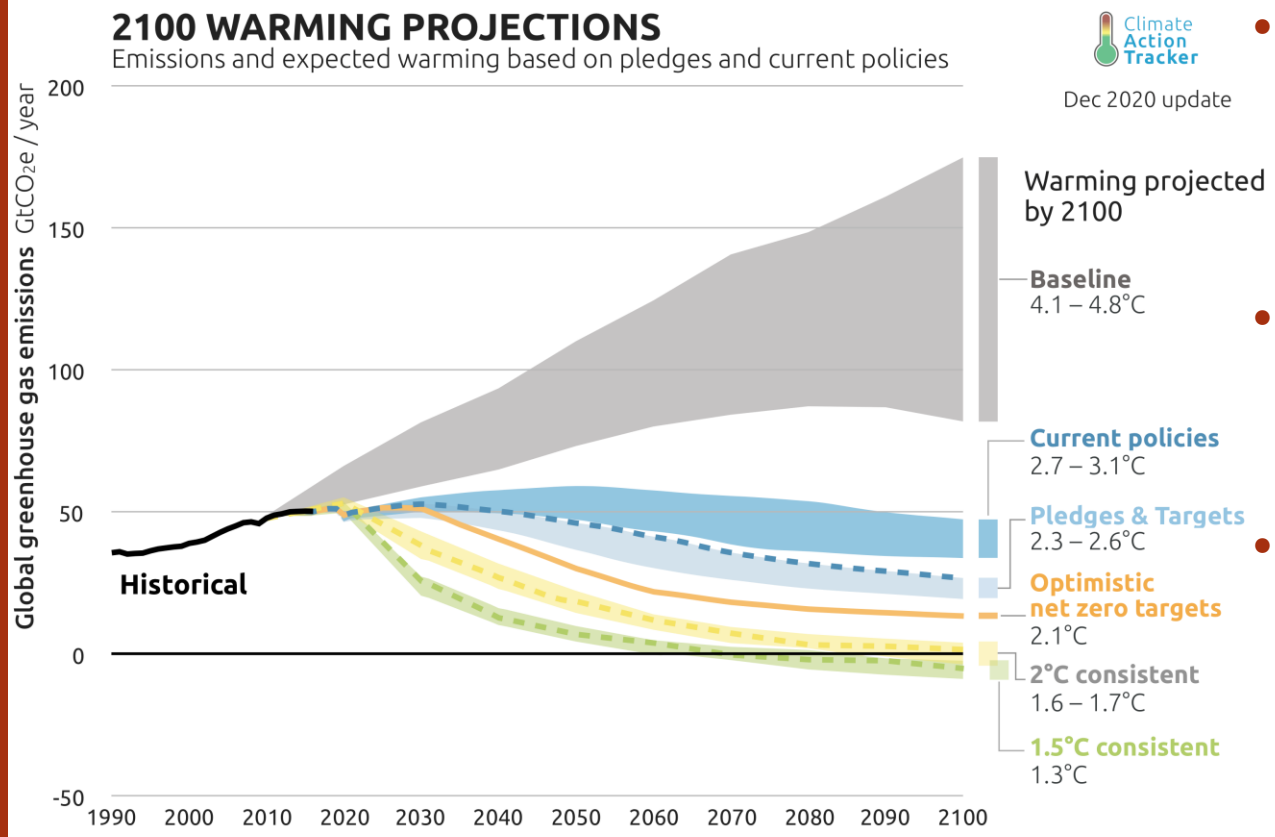
- Climate change is displacing people from their homes around the world.
  - Rising sea levels are displacing people from low lying regions and island nations.
  - Desertification and permafrost melt are making some areas uninhabitable.
  - Destruction of homes and property by extreme weather.
  - Increased frequency and severity of disease outbreaks.
  - Intensifying intra / inter-state competition and conflict over food, water, and other resources whose supply is impacted by climate change.
- Many migrations are temporary, but some that start out as temporary, become permanent(Hurricane Katrina).
- Many migrants are migrating from the least developed regions of sub-Saharan Africa, northern Africa, southeast Asia, and Latin America.
  - In 2018, 143 million people were forced to emigrate from these regions due to sudden onset weather events or humanitarian crises fueled in part by climate change.
- Increasing numbers of people migrating to new regions will test the limits of national and international governance and cooperation.

Kyoto Protocol, 1997

- 127 nations came together in 1997 in Kyoto, Japan to sign a treaty pledging to reduce emissions of six greenhouse gases (CO_2, CH_4, N_2O, and 3 specific Halocarbons) to less than 1990 levels, between 2008 and 2012.
- The obligation to reduce emissions during this period was placed on the most developed countries who ratified the treaty (36 nations), since they were the nations primarily responsible for past emissions.
- The U.S. was the only developed nation that did not ratify the Kyoto protocol. India and China were not considered among the most developed countries at the time, and not responsible for reducing emissions under the terms of the treaty between 2008 and 2012.
- All 36 countries that participated eventually met their targets, although some did so by paying for carbon reductions in less developed countries to offset their own carbon emissions. Global carbon emissions still increased32% between 1990 and 2010.
- Negotiations to set new legally binding targets were unsuccessful after several attempts, but did result in the Paris accord.



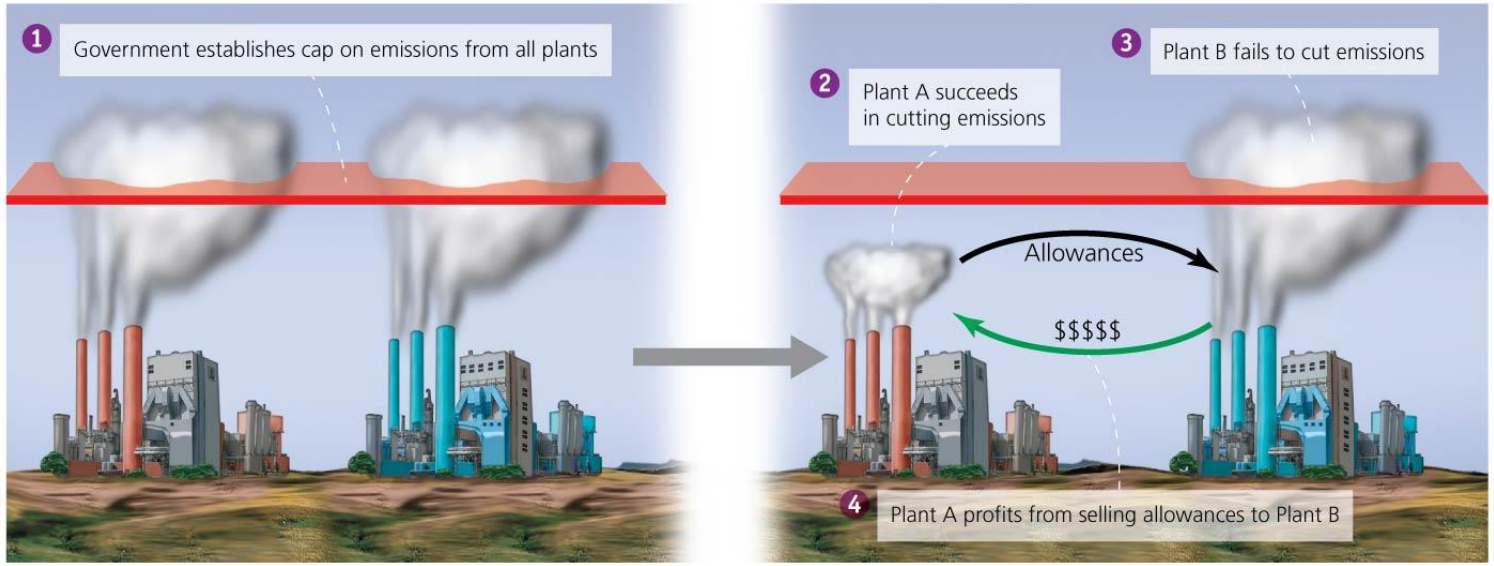
Paris Accord, 2016



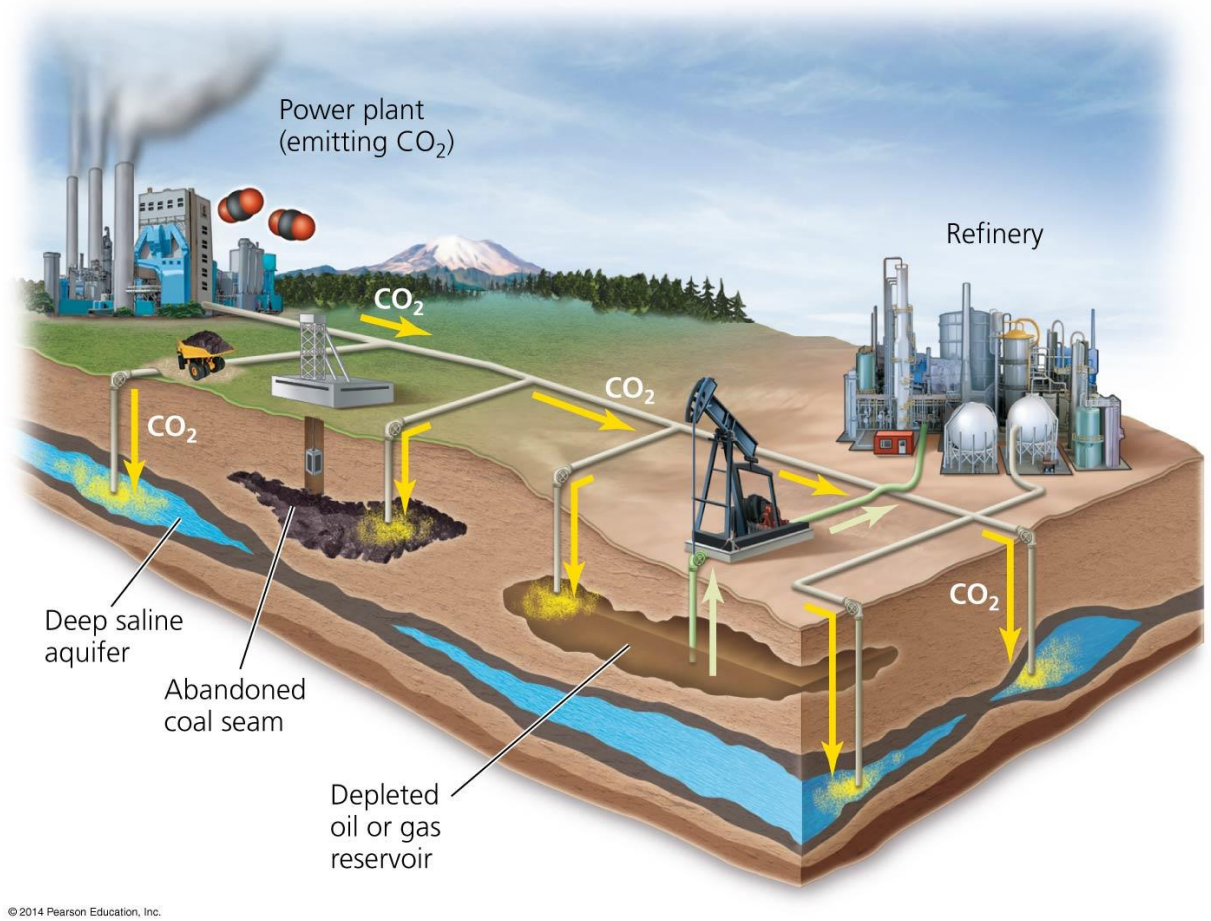
- An agreement among 196 nations to cut carbon emissions through bottom- up, voluntary contributions.
- Allows countries to determine their own "Nationally Determined Contributions" (NDC's) to cutting atmospheric Carbon dioxide (or its equivalents in other GHG's).
- Although countries can set their own NDC's, NDC's are required to become more ambitious over time (recommended every 5 years)
- Goals of the Paris Accord are to limit global warming to less than 2℃ by 2100 as compared to preindustrial temperatures, and ideally keep warming to less than 1.5℃ by 2100
  - Current NDC pledges are not enough to prevent increases in atmospheric CO_2, let alone reduce CO_2e to a point where climate warms less than 2℃ or 1.5℃ compared to the preindustrial global temperature average.

Cities and states are leading the way with climate change policy in the U.S.

- In the absence of any Federal legislation regulating GHG's, and no international commitments, cities and states have set their own laws goals and passed legislation to limit warming.
  - Mayors of over 1000 U.S. cities have signed the ***U.S. Mayors Climate Protection Agreement*** in which cities commit to meeting or beating Kyoto Protocol guidelines.
  - California passed the ***Global Warming Solutions Act*** (2006), successfully reducing current emissions 25% below 1990 levels, and amending the law in 2016 to set a new target of 40% below 1990 levels by 2030.
- California achieved these goals through investment in renewable energy, mandating higher fuel efficiency standards, and becoming the first state to enact penalties for noncompliance under a ***cap-and-trade program for trading carbon emissions***.



Other potential solutions to reducing GHG's



- ***Carbon taxes***: Industries pay per unit of CO_2e emitted, instead of being fined for exceeding a predetermined limit (cap).
- ***Carbon offsets***: Participants voluntarily pay other entities to remove an amount of carbon equivalent to what they produce in order to achieve carbon neutrality.
  - The cost of Carbon offsets are often cheaper than reducing carbon emissions
- ***Carbon capture and sequestration***: refer to technologies that allow for removal of carbon from the atmosphere and storage underground.
  - Some technologies use almost as much energy, and release almost as much CO2, in the process of sequestering carbon.
  - How much carbon can we store in the long run?

We will need to reduce emissions from multiple industries to limit climate change

Energy use and electricity production

- We can switch to cleaner energy sources
  - Natural gas is far cleaner (less CO_2, SO_2, and mercury) than coal.
  - Nuclear, solar, wind, hydroelectric, geothermal, and ocean energy all have no GHG emissions.
- Improve energy conservation and efficiency
  - More efficient appliances (LED lighting, energy star products)
  - More efficient construction (Higher R-value insulation and double paned, low–E windows.
  - Use of cogeneration by energy utilities.
- Changes to Transportation
  - Improved technology and increased availability of hybrid, electric, and fuel cell vehicles.
  - Improvements to public transit and how walkable or bikeable urban areas are due to urban planning.

Agriculture

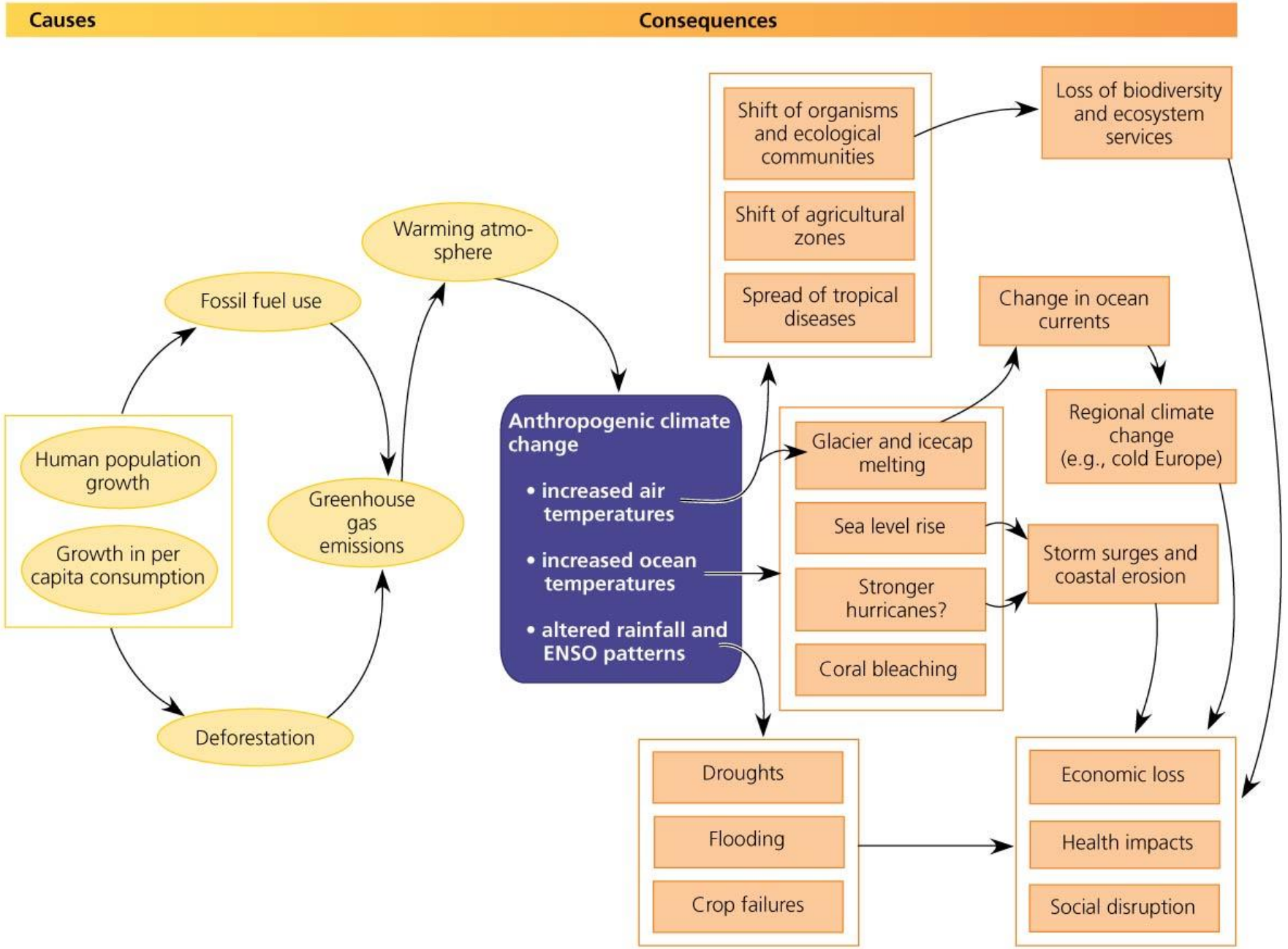
- Limit methane production from sewage lagoons or capture it to use as fuel (natural gas).
- Reduction of synthetic fertilizer use to reduce N_2O.
- Practice no till agriculture which leaves soils less disturbed, allowing more effective carbon sequestration.

Forest management

- Preserve existing forests and practice more sustainable forestry practices.
- Reforest cleared lands.

Waste management

- Methane recovery from landfills for electricity.
- Electricity generation from waste incineration.
- Recycling saves energy of mining virgin materials.


Causes
Consequences
Human population growth
Growth in per capita consumption
Fossil fuel use
Deforestation
Greenhouse gas emissions
Warming atmo-sphere
Anthropogenic climate change
• increased air temperatures
• increased ocean temperatures
• altered rainfall and ENSO patterns
Shift of organisms and ecological communities
Shift of agricultural zones
Spread of tropical diseases
Loss of biodiversity and ecosystem services
Change in ocean currents
Regional climate change (e.g., cold Europe)
Glacier and icecap melting
Sea level rise
Stronger hurricanes?
Coral bleaching
Storm surges and coastal erosion
Droughts
Flooding
Crop failures
Economic loss
Health impacts
Social disruption