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Climate Change

Bashayer Madi

Co-Academic Programs

Faculty of Health Sciences

University of Balamand

Lebanon Eco Movement
الحركة البيئية اللبنانية

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An Enormous Cloud of Air Pollutants and Ash from Mt. Pinatubo on June 12, 1991. The volcano exploded in a catastrophic eruption in the Philippines, killing hundreds. Sulfur dioxide and other gases emitted into to the atmosphere by the eruption circled the globe, polluted the air, reduced the sunlight reaching the earth's surface and cooled the atmosphere for 15 months.

Global Warming & Global Cooling

Bashayer Madi, Co-Academic Programs,
FHS, University of Balamand

Global Warming and Global Cooling
Are Not New

- Over the past 4.7 billion years the climate has been altered by: **Volcanic emissions**, **Changes in solar input**, **Movement of the continents**, **Impacts by meteors** and **Changing global air and ocean circulation**

- Over the past years → the atmosphere experienced prolonged periods of alternating cycles of thawing and freezing → leading to global warming and global cooling → **Glacial and interglacial periods**

Refer to: https://www.youtube.com/watch?v=oJAbATJCugs

- **However:** The temperature began rising during the last century

❑ Global Warming:

- The temperature increase in the troposphere, which in turn can cause climate change

➔Caused by Natural changes (volcanic emissions, shifting tectonic plates) and Human activities (**Clearing of forests, agriculture and burning of fossil fuels**)

❑ Global Climate Change:

- broader term that refers to→ changes in any aspects of the earth's climate, including temperature, precipitation and storm.

- Why worry about a possible rise of only few degrees … as long as we experience such a rise between May and July, for example????

We are not talking about a normal change in the local weather …. but a projected global climate change … weather averaged over decades

And

The concern is not how much temperature changes, but rather how unexpectedly fast it occurs

The Intergovernmental Panel on Climate Change (IPCC)

Established by the United Nations Environment Program (UNEP) and the World Meteorological Organization (WMO) in 1988

- To provide **clear scientific** view on the current state of knowledge in climate change and its potential environmental and socio-economic impacts.
- It **does not** conduct any **research** nor does it **monitor climate related data or parameters**.

➔ It reviews and assesses the most recent scientific, technical and socio-economic information produced worldwide relevant to the understanding of climate change.

- Document **past** climate changes and **project** future changes

Leading international scientific body for the assessment of climate change. The IPCC is a scientific body under the auspices of the United Nations (UN).

- Scientists developed mathematical models to project effects of climate change and analyze past T° changes

Ice cores from ancient glaciers

Plankton in ocean sediments

T° measurements at different depths in boreholes drilled into earth's surface

Pollen from bottoms of lakes

Historical records

Ice Cores are Extracted by Drilling Deep Holes in Ancient Glaciers

Ice cores are extracted by drilling deep holes into ancient glaciers at various sites near the South Pole in Antarctica. Thousands of these ice cores, containing valuable climate and other data, are stored in places such as the National Ice Core Laboratory in the U.S. city of Denver, Colorado. Scientists analyze tiny air bubbles, layers of soot, and other materials trapped in different layers of these ice cores to uncover information about the past composition of the lower atmosphere and temperature trends.

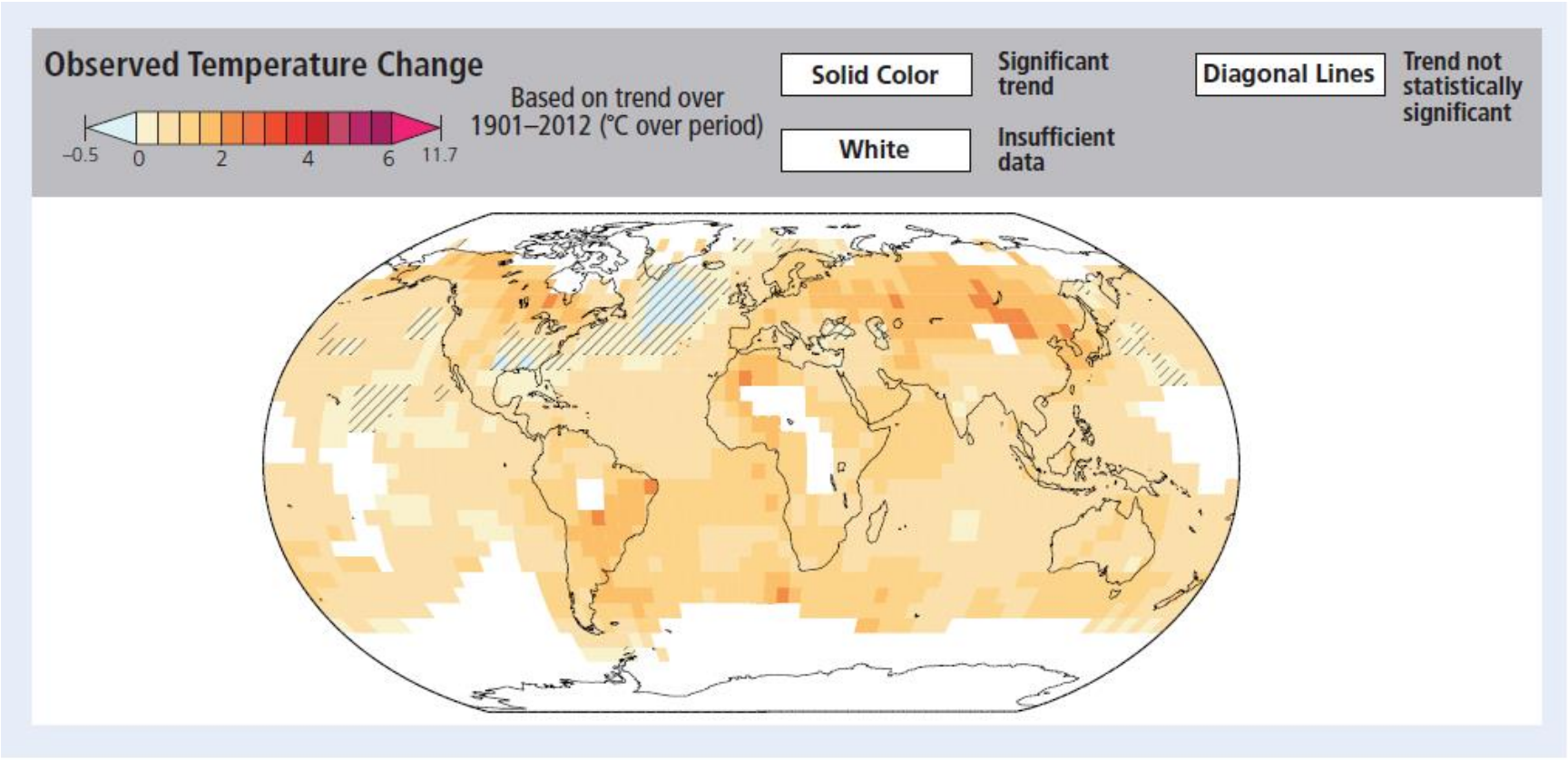
The IPCC reported:

- Troposphere is getting warmer.
- Each of the last three decades has been successively warmer at the Earth's surface than any preceding decade since 1850.
- The period from 1983 to 2012 was likely the **warmest 30-year period** of the last 1400 years in the Northern Hemisphere, where such assessment is possible.
- The globally averaged combined land and ocean surface temperature data as calculated by a linear trend show a warming of **0.85** [0.65 to 1.06] °C over the period 1880 to 2012.
- Almost the entire globe has experienced surface warming.
- Oceanic uptake of CO2 has resulted in acidification of the ocean; the pH of ocean surface water has decreased by 0.1 (high confidence), corresponding to a 26% increase in acidity, measured as hydrogen ion concentration.

The IPCC reported (Cont'd):

- Arctic **temperature** have **risen** almost twice as fast as those in the rest of the world.
- Over the period 1992 to 2011, the Greenland and Antarctic **ice sheets** have been **losing** mass.
- Glaciers & floating sea **ice Glaciers** have continued to **shrink** almost worldwide.
- Northern Hemisphere **spring snow cover** has continued to **decrease** in extent.
- The annual mean Arctic **sea-ice** extent **decreased** over the period 1979 to 2012 (3.5 to 4.1% per decade).
- **Warmer temp** in Alaksa & Russia.
- The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, and sea level has risen.
- Over the period 1901 to 2010, global mean **sea level** rose by 0.19 [0.17 to 0.21] m (**19 cm**).

Observed Temperature Change



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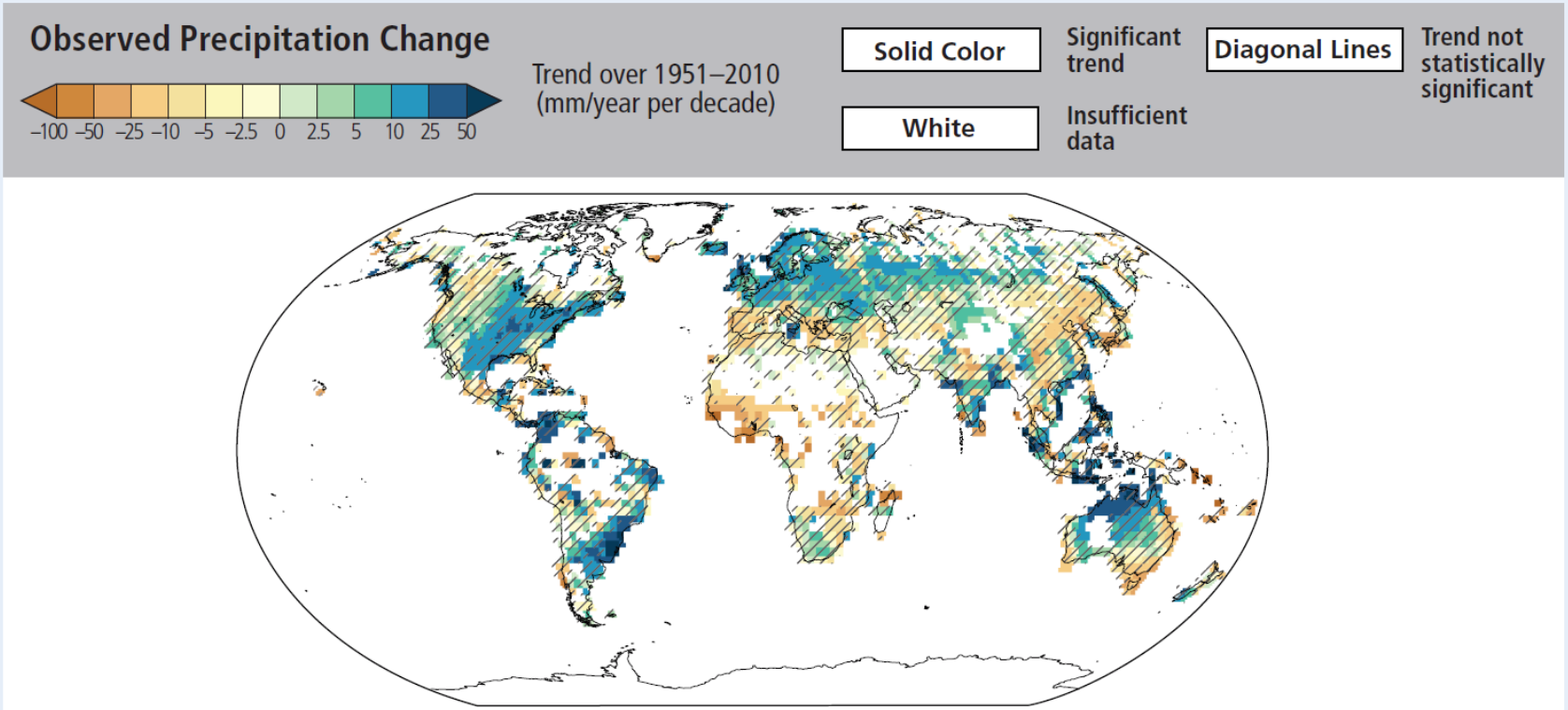
Observed Precipitation Change



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Human Impact on Climate Change

- Human influence on the climate system is clear, and recent anthropogenic emissions of greenhouse gases are the highest in history.

- Recent climate changes have had widespread impacts on human and natural systems.

Factors Affecting the Earth's Temperature

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FHS, University of Balamand

- There are several natural and human factors that would either **amplify** (positive feedback) or **dampen** (negative feedback) the average temperature of the troposphere:

1. **Effect of Oceans**
2. **Effect of Cloud Cover**
3. **Effect of High CO_2 Levels on Photosynthesis**
4. Effect of Warmer Troposphere on Methane Emissions
5. Effect of Outdoor Air Pollution

1. Effect of Oceans

The **ocean helps moderate** the earth's average temperature by:

- Removing almost ½ of the excess CO_2 human activities pump into the atmosphere.
- **Absorbing heat** from the troposphere & slowly transferring some of it to the deep ocean (removed from the climate system for unknown period of time).

➔ **Reducing the Global Warming**

- But, the solubility of CO_2 in ocean water ⬇ with temperature → if oceans heat up, some of its CO_2 could be released into the atmosphere

➔ **Increase the Global Warming**

➔ how much CO_2 & heat the oceans can remove from the troposphere & how long the heat & CO_2 might remain there → still very uncertain

2. Effect of Cloud Cover

Warmer temperature increase evaporation of surface water & create more clouds

The clouds:

- Absorb & release heat into the troposphere

→**Increase the global warming**

- Reflect more sunlight back into the space

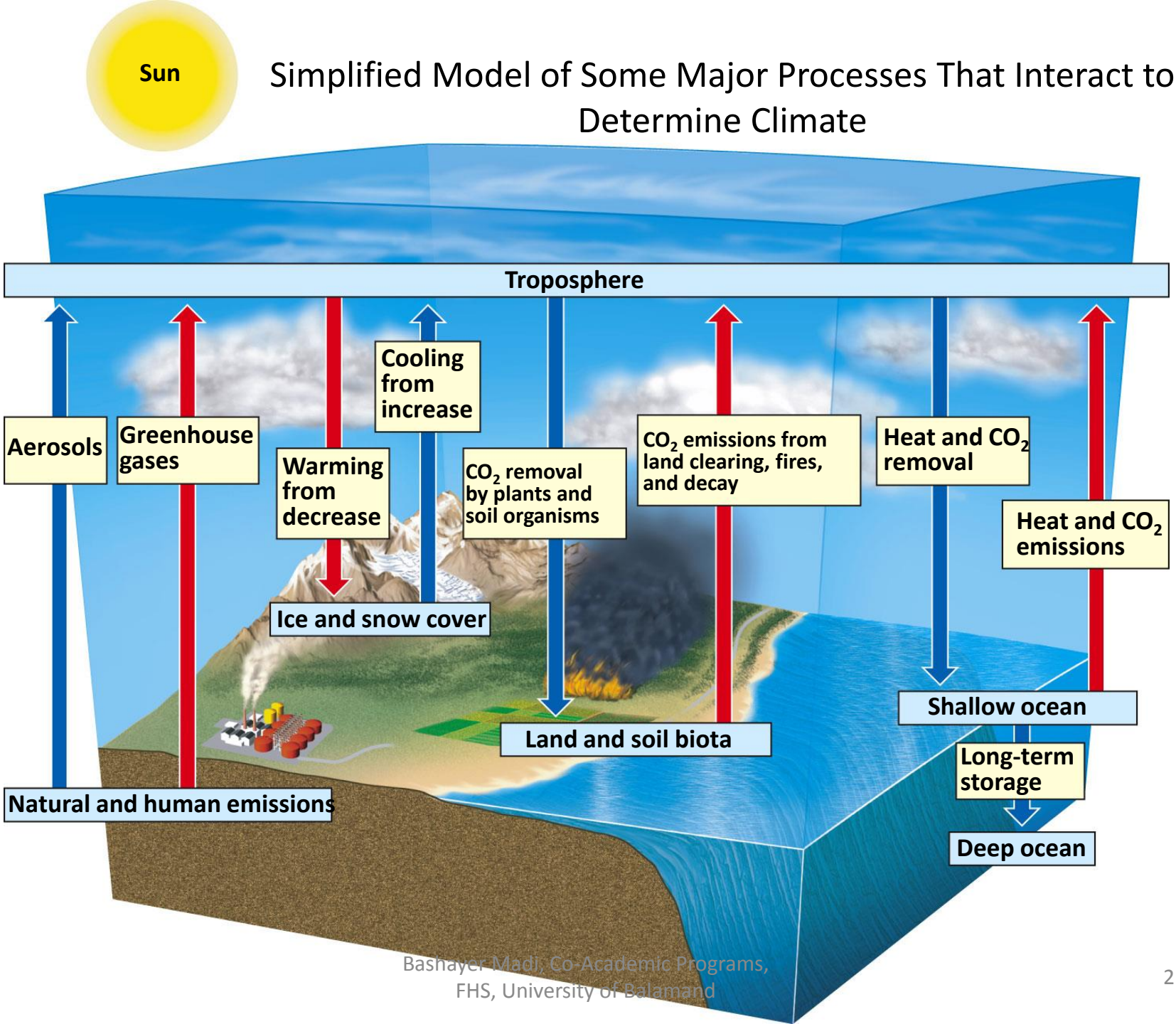
→**Reduce the global warming**

3. Effects of High CO_2 Levels on Photosynthesis

- Large amounts of CO_2 in the atmosphere → could increase the rate of photosynthesis (adequate water and soil nutrients) → removal of CO_2 from the atmosphere → **Reduce the global warming**

- The increase in photosynthesis would slow as the plants reach maturity & use up less CO_2 from the troposphere → Carbon stored in the plants will return to the atmosphere as CO_2 when the plants die & decompose or burn → **increase the global warming**

Simplified Model of Some Major Processes That Interact to Determine Climate



Greenhouse Effect & Greenhouse Gases

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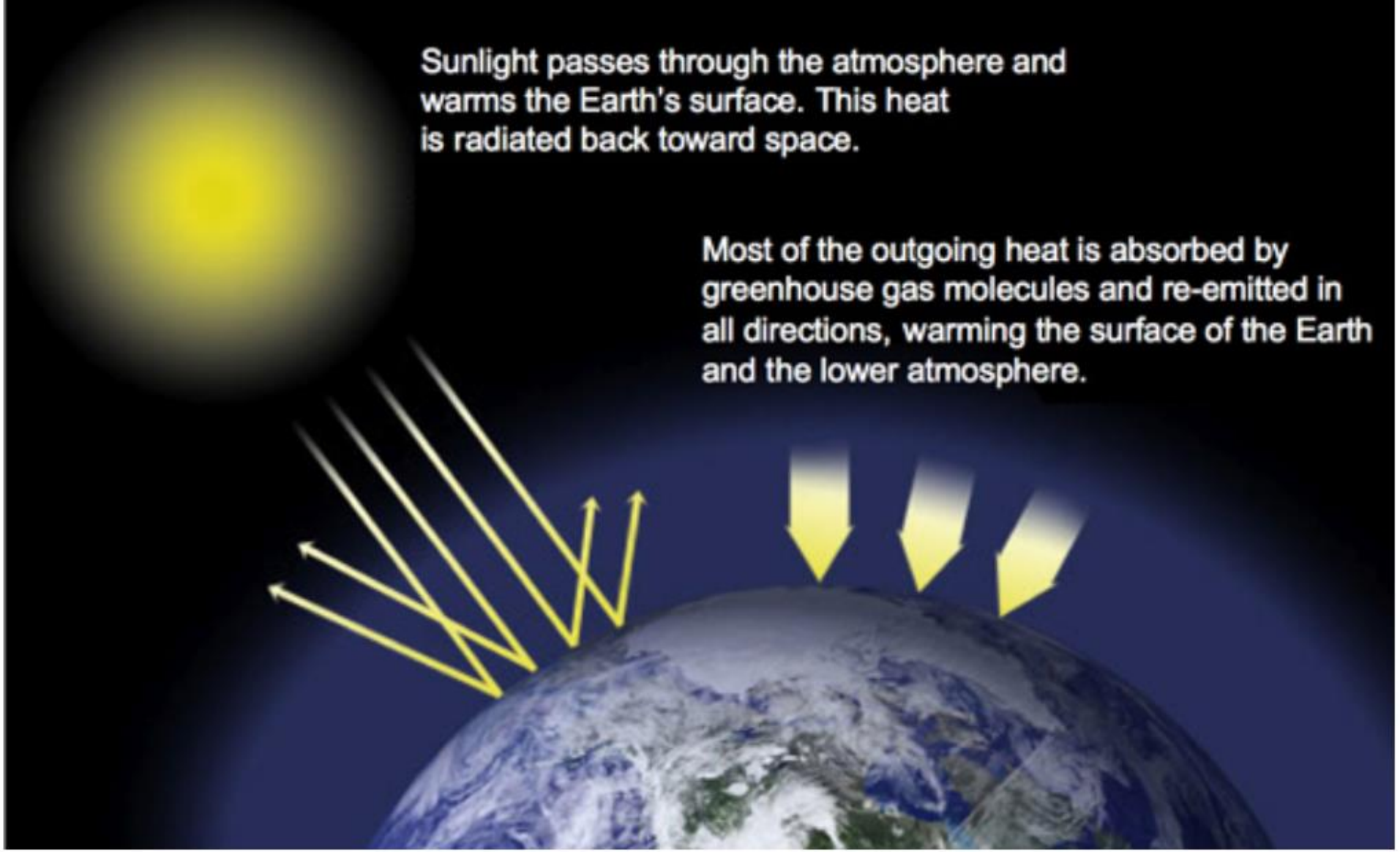
2. Greenhouse Effect and Greenhouse Gases

Three major factors shape the earth's climate:

- **Sun:** without **solar energy** →the earth would be dark and freezing→ no life.

- **Oceans:** Influence climate by **storing** carbon dioxide & heat, **evaporating** & **receiving** water as part of the hydrological cycle and **moving stored heat** from one place to another in currents.

- **Greenhouse effects (natural process):** It warms the earth's lower troposphere & surface because of the presence of several gases called the **Greenhouse Gases.**



A layer of greenhouse gases – primarily water vapor, and including much smaller amounts of carbon dioxide, methane and nitrous oxide – acts as a thermal blanket for the Earth, absorbing heat and warming the surface to a life-supporting average of 59 degrees Fahrenheit (15 degrees Celsius). NASA. (2017). Global Climate Change: Vital Signs of the Planet. Retrieved from: https://climate.nasa.gov/causes/

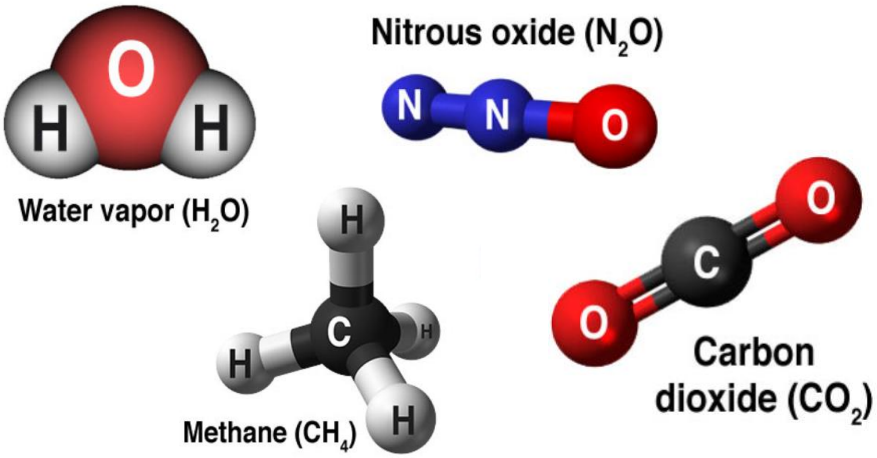
The solar energy absorbed by the earth is radiated back into the atmosphere as heat (infrared radiation).

The sunlight passes through the atmosphere and warms the earth's surface; however, the heat produced by the sunlight is radiated back into the space.

The radiated heat by the earth is absorbed by the molecules of the greenhouse gases ➔ causing them to vibrate and release infrared radiation with longer wavelength into the troposphere.

This radiation would interact with molecules in the atmosphere and increase their kinetic energy. Thus, warming the troposphere and the earth's surface and in turn affecting the earth's climate.

The natural greenhouse gases in the troposphere are:



Refer to: https://www.youtube.com/watch?v=oJAbATJCugs

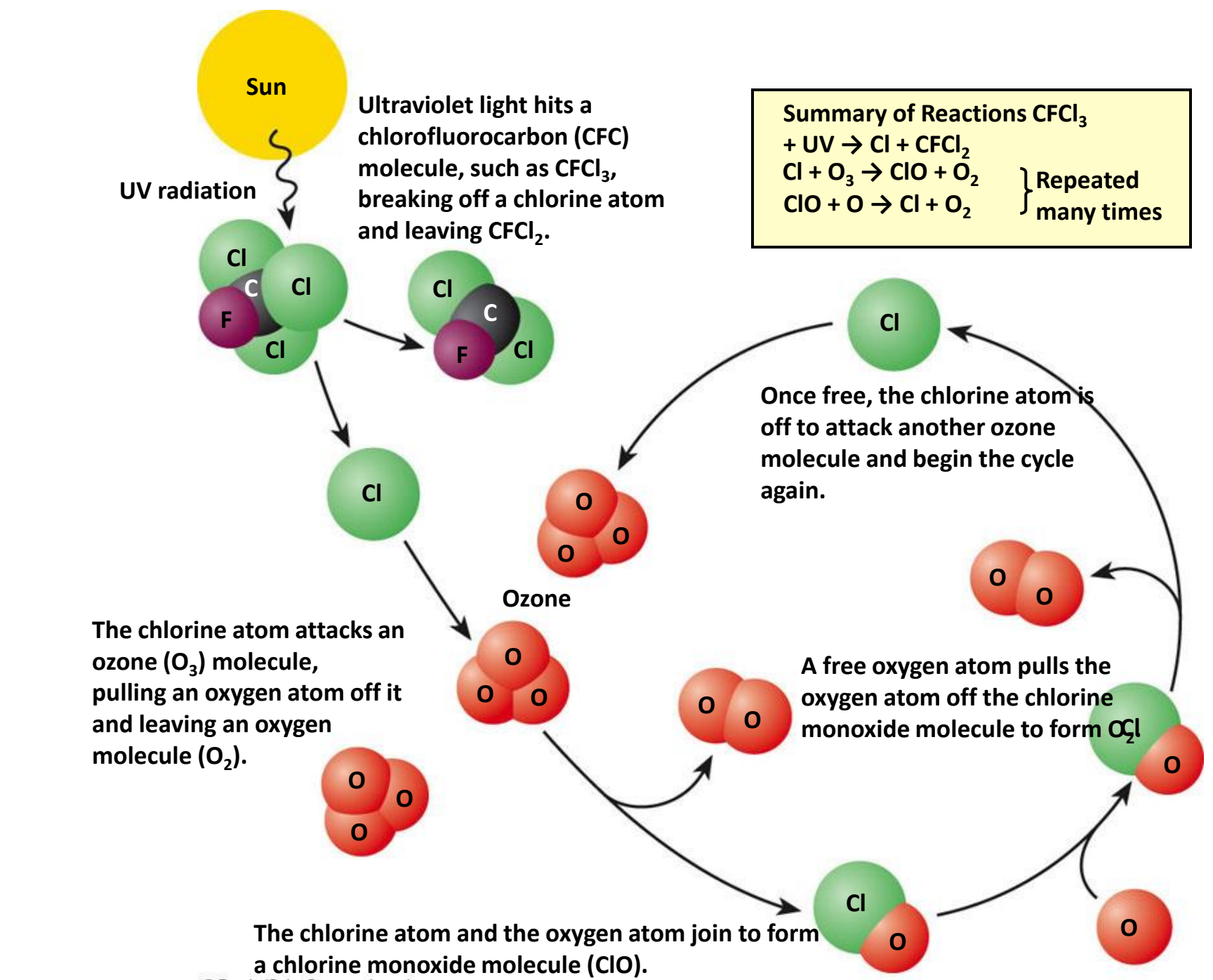
The Fluctuations in the concentrations of these **gases** in the troposphere + changes in **solar output**

➔**major factors causing the change in the average temperature of the troposphere**

Greenhouse Gases

F-gases Hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride➔ referred to high Global Warming Potential

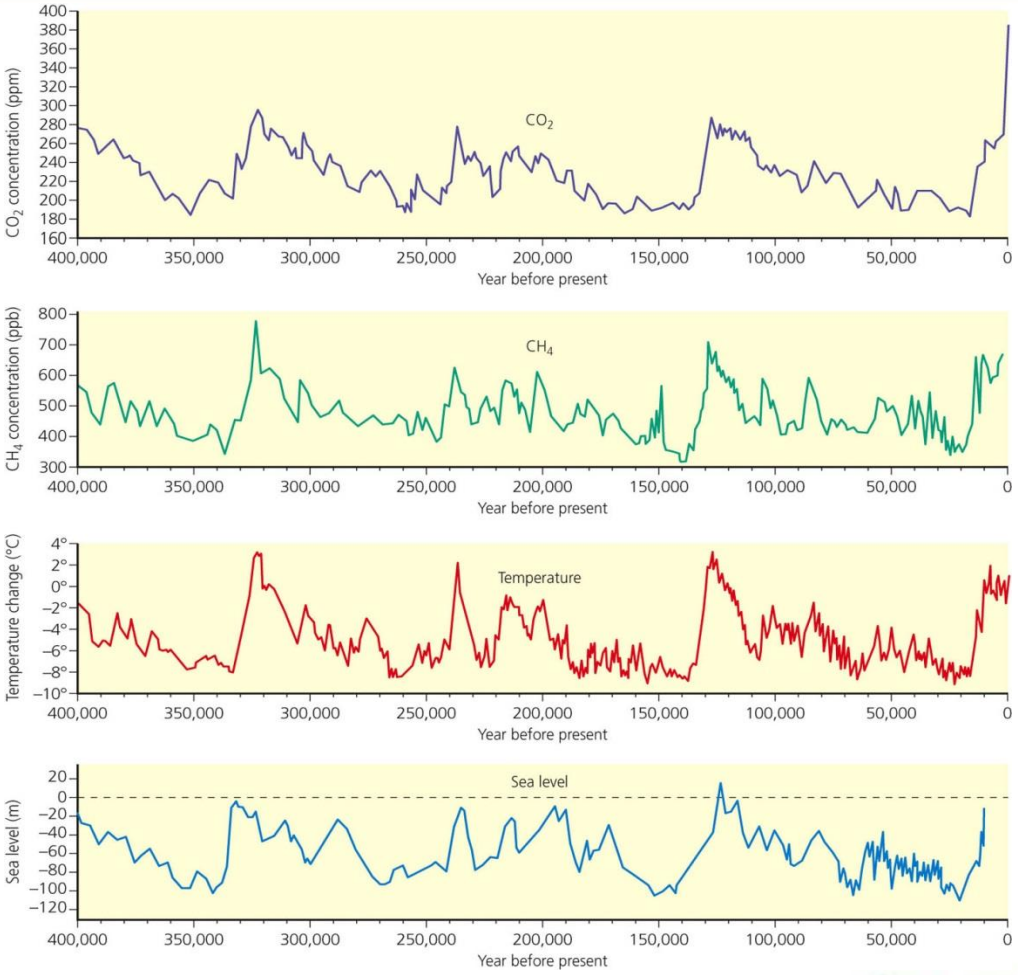
Hydrofluorocarbons are used as substitutes for ODS (chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), and halons)



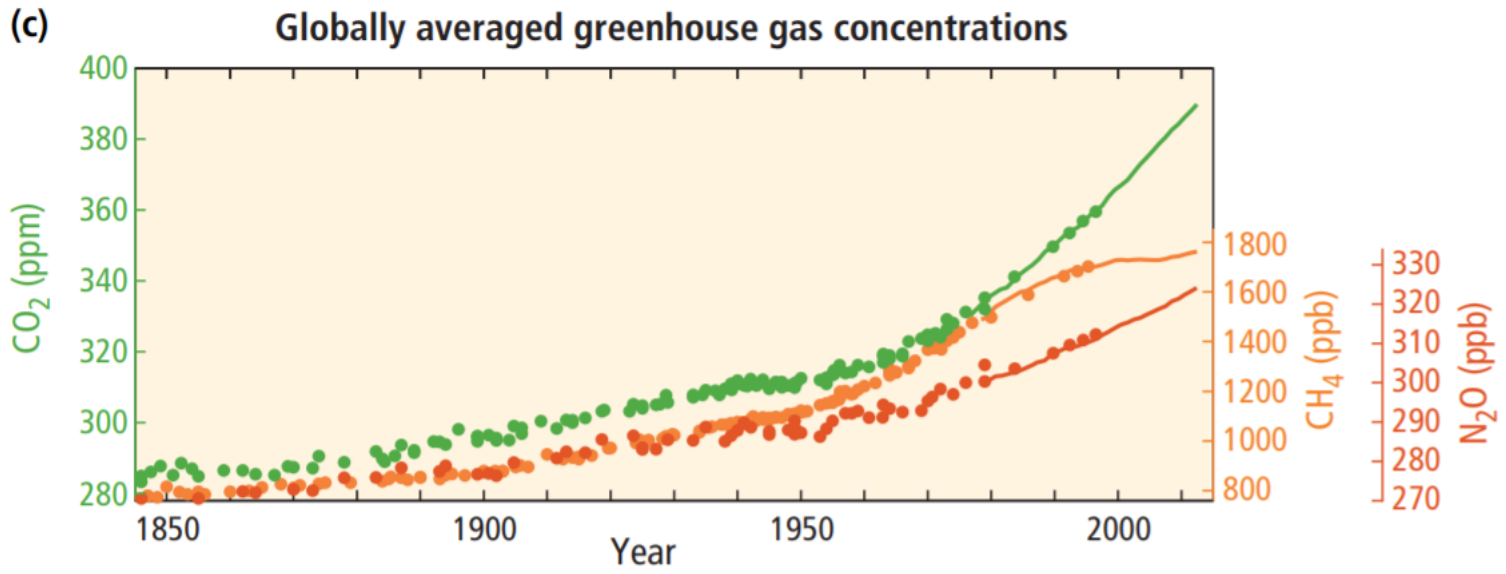
Atmospheric Levels of CO_2 and CH_4, Global Temperatures, and Sea Levels

- Carbon dioxide remains in the atmosphere for 80–120 years compared to about 15 years for methane.

- However, each molecule of methane has 25 times the warming potential of a molecule of carbon dioxide



Atmospheric Levels of GHGs



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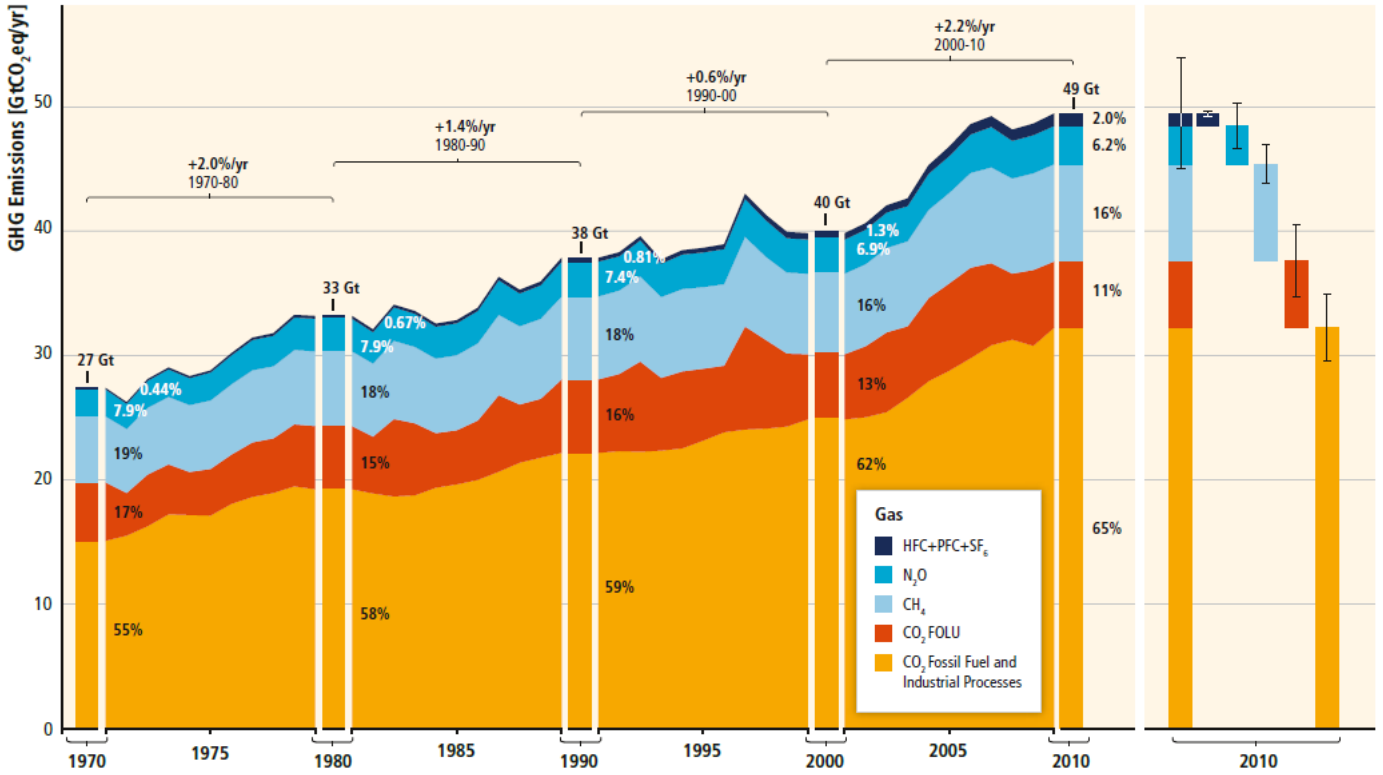
Atmospheric Levels of GHGs



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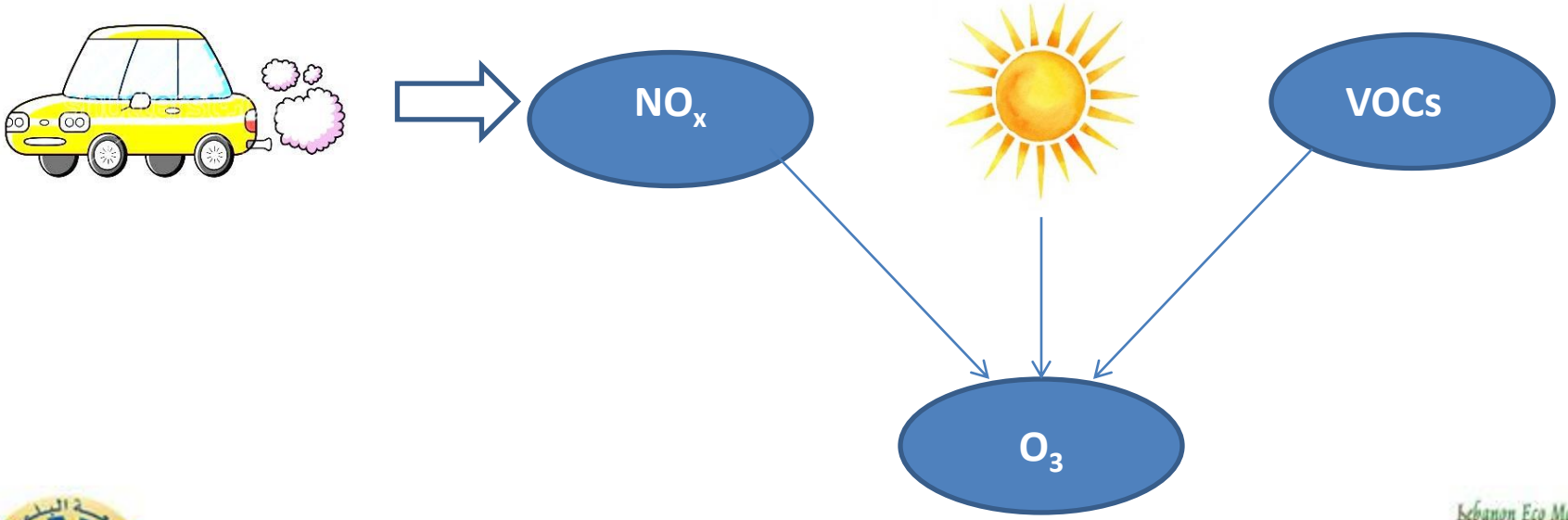
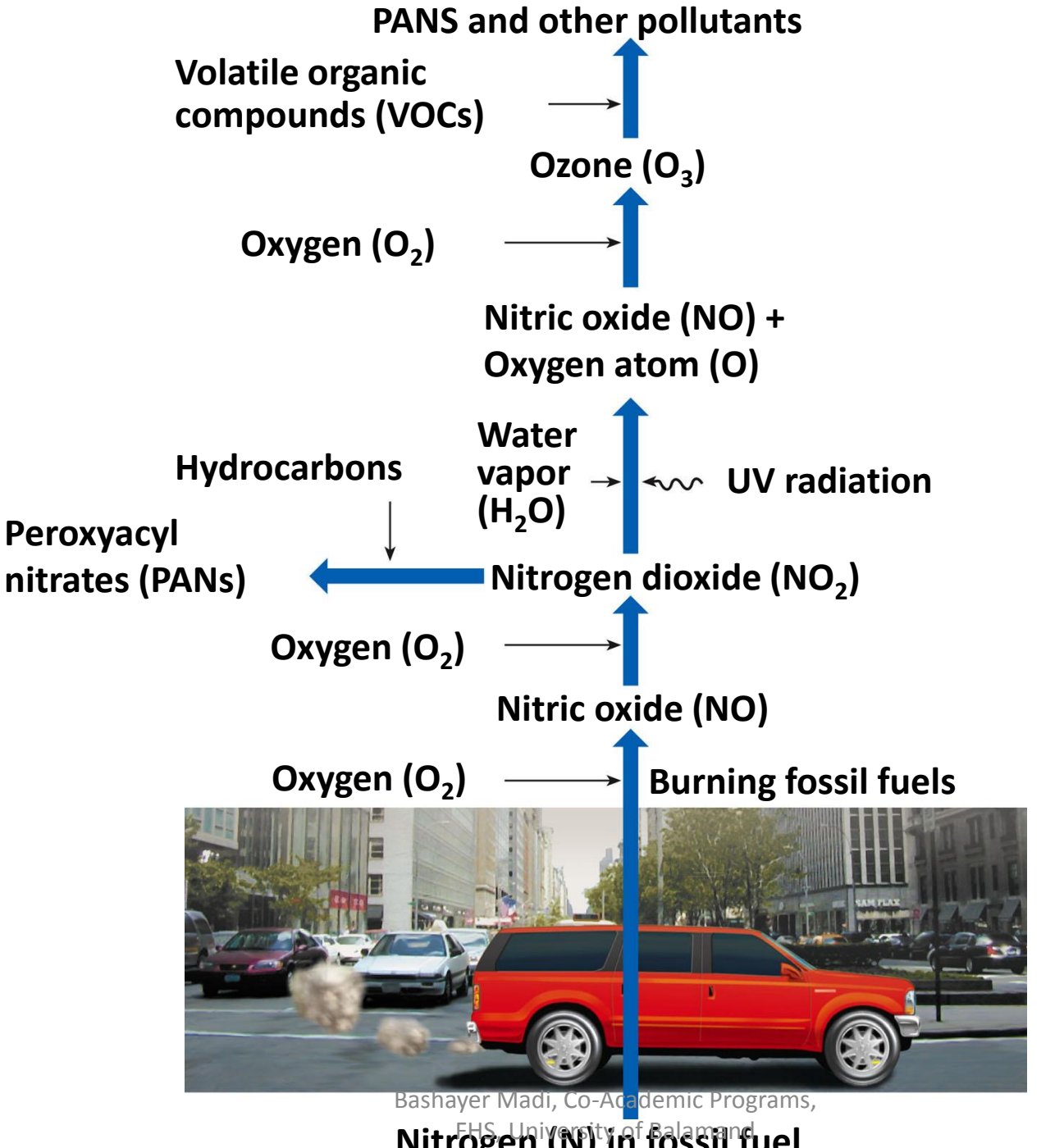
Aerosols and tropospheric ozone contributes to trends in climate forcing. But since their impact is shortly lived they are not discussed in terms of concentrations in climate.

They are discussed in terms of radiative forcing: radiative energy budget of the Earth.

Photochemical smog: It is a mixture of primary and secondary pollutants (NOx)formed under the influence of UV radiation from the sun.

1. It begins when the exhaust from morning commuter vehicles releases large amounts of **NO and VOCs** into the air over a city.
2. The NO is converted to reddish brown color (NO_2)




PANS and other pollutants
Volatile organic compounds (VOCs)
Ozone (O_3)
Oxygen (O_2)
Nitric oxide (NO) + Oxygen atom (O)
Water vapor (H_2O)
UV radiation
Hydrocarbons
Peroxyacyl nitrates (PANs)
Nitrogen dioxide (NO_2)
Oxygen (O_2)
Nitric oxide (NO)
Oxygen (O_2)
Burning fossil fuels
Nitrogen (N) in fossil fuel

What's Radiative forcing?

Bashayer Madi, Co-Academic Programs,
FHS, University of Balamand

Radiative forcing is a measure of how the energy balance of the Earth-atmosphere system is influenced when factors that affect climate are altered.

The word radiative arises because these factors change the balance between incoming solar radiation and outgoing infrared radiation within the Earth's atmosphere.

This radiative balance controls the Earth's surface temperature.

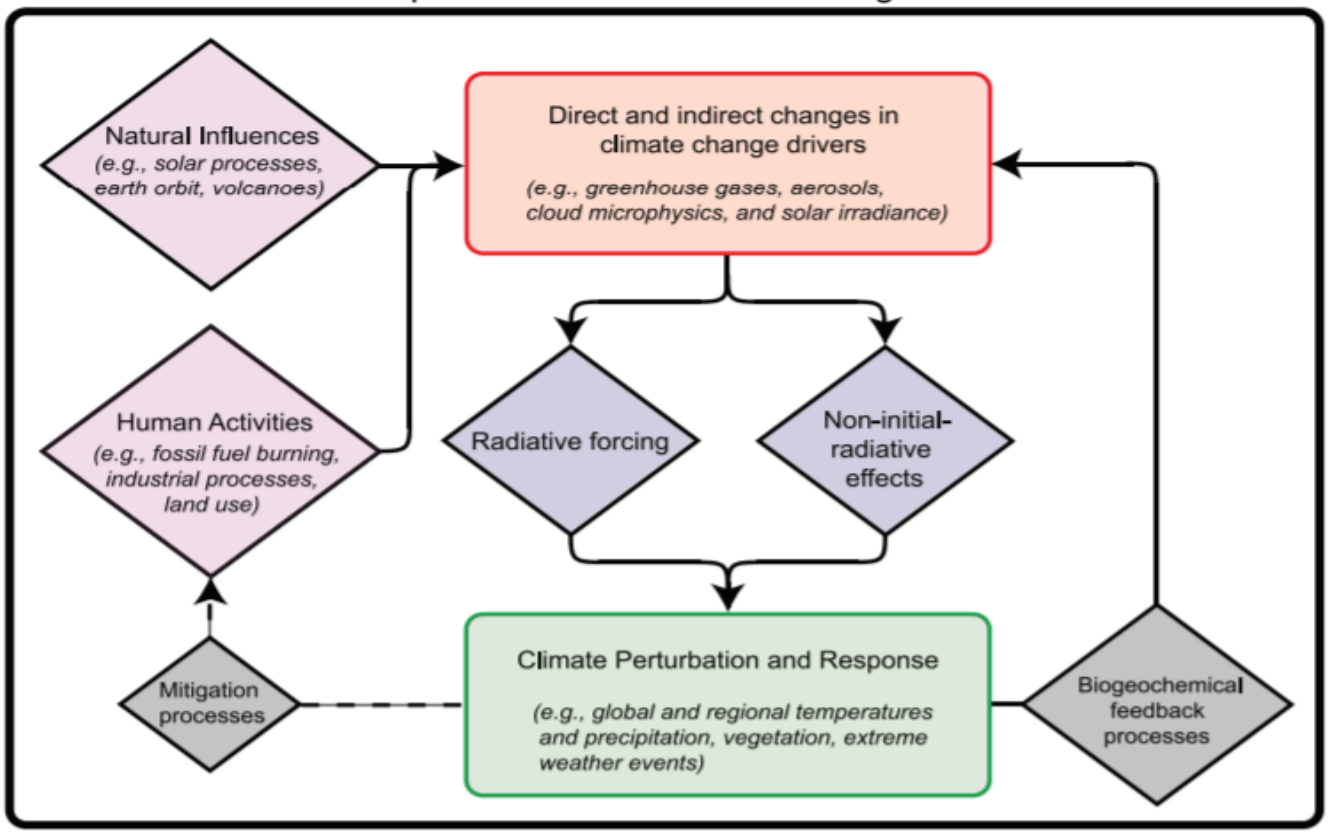
The term forcing is used to indicate that Earth's radiative balance is being pushed away from its normal state.

Radiative forcing is usually quantified as the 'rate of energy change per unit area of the globe as measured at the top of the atmosphere', and is expressed in units of 'Watts per square metre'.

Positive radiative forcing ➔ the energy of the Earth-atmosphere system will ultimately increase ➔ leading to a warming of the system.

Negative radiative forcing, ➔ ultimately decrease ➔ leading to a cooling of the system.

Components of the Climate Change Process



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CO_2 1st imp GHG

- Burning Fossil Fuels (industries) coal, oil & gas
- Deforestation /Clearing forests
- Burning forests, wood products and solid waste
- Transportation sector (vehicles, marine transportation, air travel and rail)
- Manufacturing cement & flaring
- Production of metals such as steel & iron
- Building heating & cooling

CH_4 2nd Imp GHG

- Agriculture(belching of livestock & rice cultivation)
- landfills (decomposition of organic waste)
- Extracting, production & transport of fossil fuel
- Melting of the permafrost soil
- Natural gas distribution

N_2O

- Agriculture (inorganic/synthetic fertilizers)
- Burning of fossil fuel (especially transportation fuel and industries)
- Breakdown or animal urine or manure
- Human waste disposal

Fluorinated gases (CFCs, HFCs, PFCs)

- Aerosol propellant, fire retardants, solvents, and refrigerants

Aerosols

- Some aerosols are <u>emitted directly</u> in the atmosphere while others are formed <u>from chemical reactions</u> from emitted compounds.
- Biomass burning and Fossil fuel increases **aerosol containing sulfur compounds, black carbon (soot)** and **organic compounds**.
- Industrial process and surface mining increases the presence of dust in the atmosphere.
- Natural dust from the surface, biogenic emissions from land and ocean, sea salt aerosols, and dust and sulfur aerosols from volcanic eruptions.
- Sulfur dioxide is emitted by combustion of fossil fuel, metal smelting and industrial processes.
- Some aerosols have negative forcing and others have positive forcing. The direct radiative forcing over all aerosols types is negative. They also cause negative forcing indirectly through changing the cloud properties.

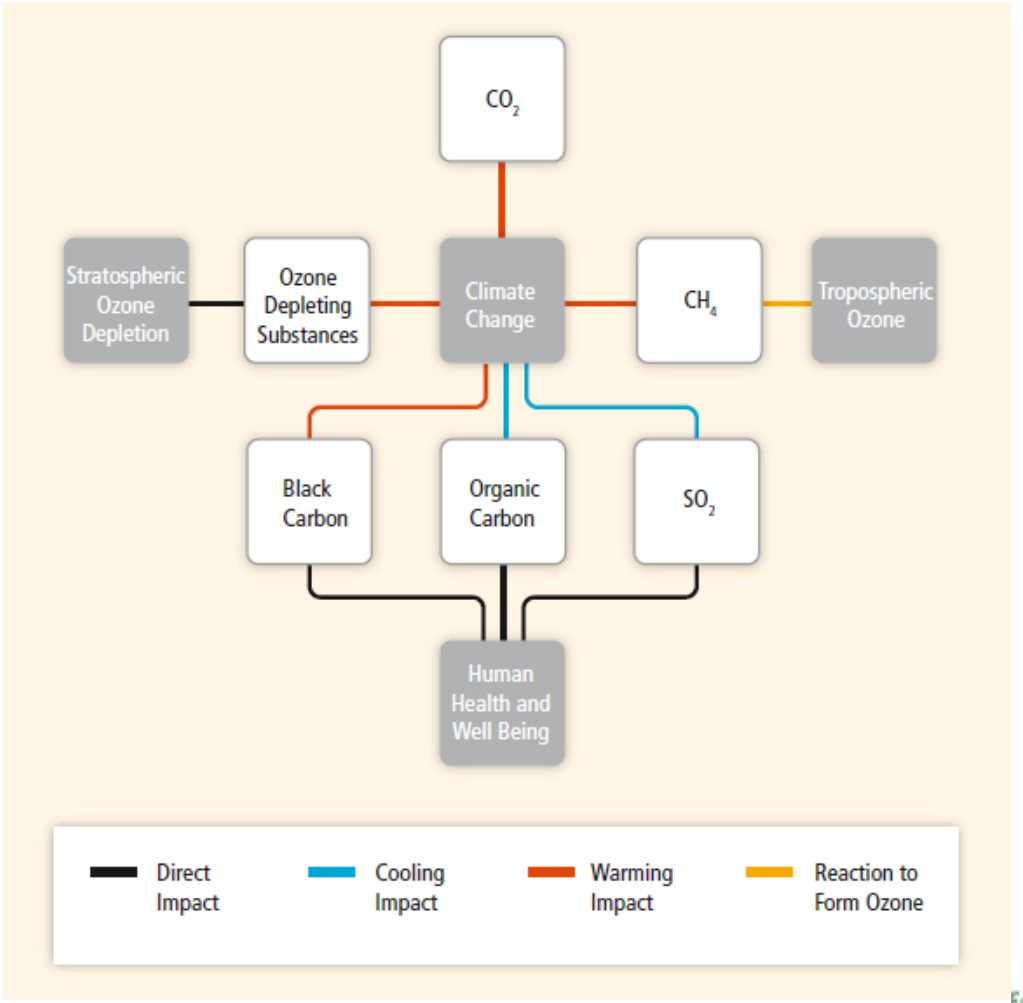
ozone:

- Tropospheric photochemical system
- Formed due to chemical reaction of NOx, CO, CH4, volatile organic compound
- Contributes a positive forcing

Water vapor:

- Humans have indirect effect on the concentrations of water vapor in the atmosphere; whereby warmer atmosphere contains high amount of water vapor.
- Example: methane (CH4) emissions undergo chemical destruction producing water vapor.

Impacts of and links between selected substances emitted to the atmosphere Adopted from (UNEP, 2012).



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Sector Drivers to GHGs Emissions

Bashayer Madi, Co-Academic Programs,
FHS, University of Balamand

Energy supply sector contribution to the GHG emissions

The energy supply sector: energy extraction, conversion, storage, transmission, and distribution processes with the exception of those that use final energy in the demand sectors (industry, transport, and building).

In 2010, the energy supply sector was responsible for **46 %** of all energy-related GHG emissions & **35 %** of anthropogenic GHG emissions.

Most of the primary energy delivered to the sector is transformed➔electricity, heat, refined oil products, coke, enriched coal, and natural gas.

Transport sector contribution to the GHG emissions

- Increasing demand for passenger and freight transport
- Urban development and sprawl
- Lack of rail and bus transit and cycle infrastructure in many regions
- Transport behavior constrained by lack of modal choice in some regions
- High fuel-consuming stock of vehicles
- Relatively low oil prices
- Limited availability of low-carbon fuels

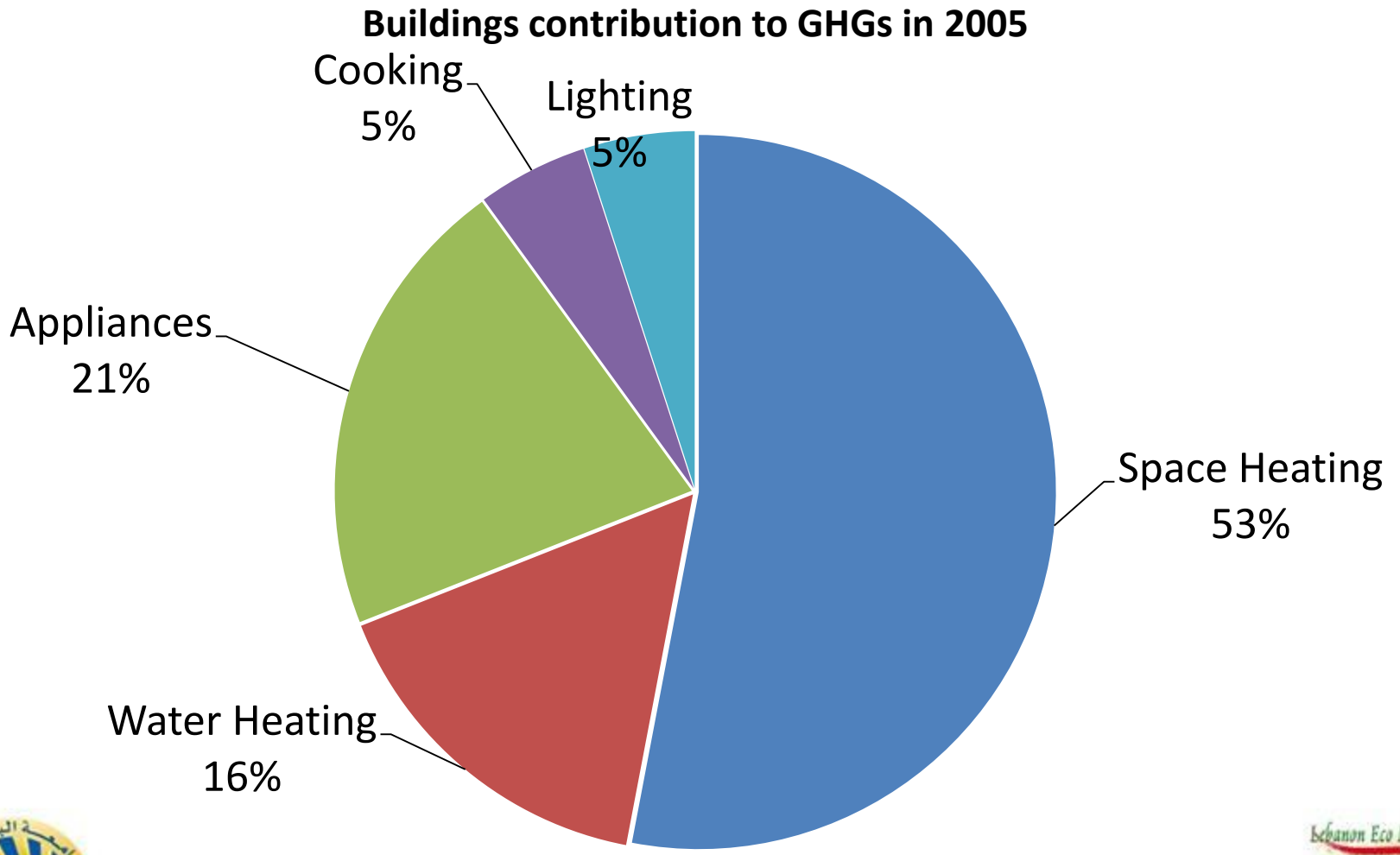
Building sector contribution to the GHG emissions

Over 80 % of GHG emissions take place during the building operation phase.

In low-income countries, a large proportion of operational energy is derived from polluting fuels: mainly wood and other biomass, such as dung and crop residues.

High number of people (2.4 billion) still use biomass for cooking and heating.

Sector: Building



Industry sector contribution to the GHG emissions

The production of energy-intensive industrial goods including cement, steel, aluminum has grown dramatically.

From 1970 to 2012, global annual production increased by:

- cement increased 500 %
- aluminum 400 %
- steel 150 %
- ammonia 250 %
- paper 200 %
- energy-intensive industries increasingly being located in developing nations.

Rapid growth in export industries has also driven emissions growth, & since 2001, China dominates in production of goods for own consumption and export.

HFC emissions have increased very rapidly, driven more by use in refrigeration equipment

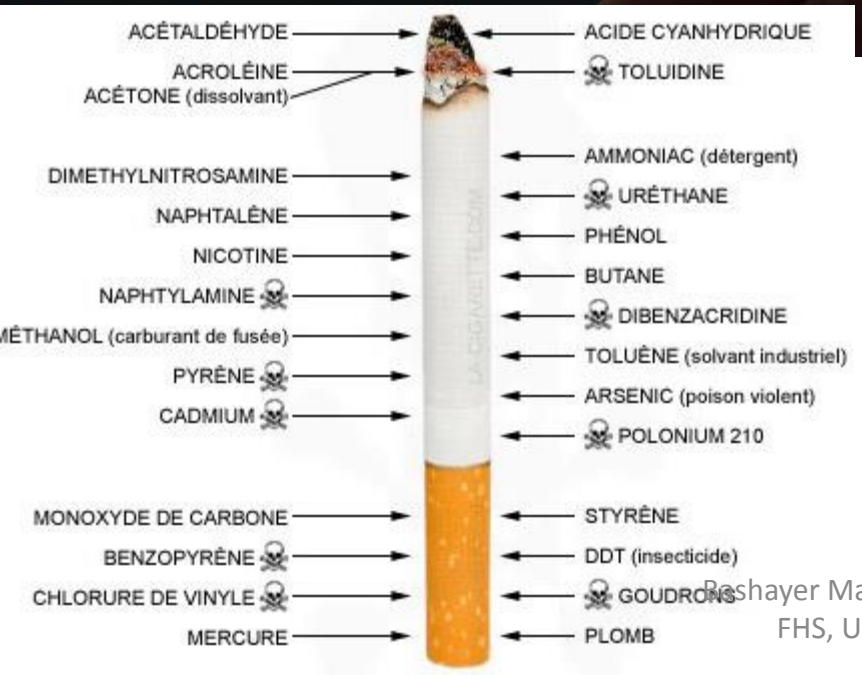
Agriculture, Forestry, Other Land Use sector contribution to the GHG emissions

- Increased demand for animal products
- Area under agriculture
- Deforestation
- Use of fertilizer (nitrogenous fertilizer)
- Area under irrigation
- Per capita food availability
- Consumption of animal products
- Increased human and animal populations

Smoking contributes to the release of greenhouse gases into the atmosphere due to **deforestation** to cut the trees to grow tobacco and to provide fuel to cure tobacco leaves. (20 to 50 million trees cut down every year to cure tobacco)

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3084482/table/t1-ijerph-08-00613/

"Tobacco smoke contains at least 172 toxic substances, including three (3) regulated outdoor air pollutants, thirty-three (33) hazardous air pollutants, forty-seven (47) chemicals restricted as hazardous waste and sixty-seven (67) known human or animal carcinogens."
Tobacco also contains radionuclides
https://www.pdx.edu/healthycampus/sites/www.pdx.edu.healthycampus/files/Environmental_Impacts.3.7.13.pdf



Waste sector contribution to the GHG emissions

The main sources of waste GHG emissions:

- solid waste disposal on land (43 % of total waste GHG emissions in 2010)
- wastewater handling (54 % of total waste GHG emissions in 2010)

Effects of Global Warming

1. Melting Ice and Snow
2. Rising Sea Levels
3. Change in Precipitation & Weather Extremes
4. Effects on Biodiversity
5. Effect on Agriculture & Fish Stocks
6. Effects on People
7. Effect on Freshwater Resources
8. Changing Ocean Currents
9. Warmer Seas

Refer to:

https://www.youtube.com/watch?v=0qO3_GEx-cI (6 degrees)

https://www.youtube.com/watch?v=G4H1N_yXBiA

1. Melting Ice and Snow:

- Some of the world's floating ice & land-based glaciers are slowly melting & are helping warm the troposphere → by reflecting less sunlight back into space.
- Glaciers are melting:
  - Himalayas in Asia
  - Alps in Europe
  - Andes in South America
- As more ice melts → the troposphere will become even warmer →more ice will melt → temperature will rise even more.

2. Rising Sea Levels:

- 0.17 to 0.21 meters → (Expansion of warm water and Melting of land-based ice)
- Threat to the coastal estuaries, wetlands, coral reefs…
- Disruption of the coastal fisheries.
- Flood agricultural lands.
- Contamination of freshwater aquifers
- Flood some areas with large human populations

4. Effects of Global Warming

3. Change in Precipitation and Weather Extremes:

Global warming will lead to

- **prolonged heat waves and droughts (extreme weather conditions)** in some areas
- **prolonged heavy rains and increased flooding** in other areas.

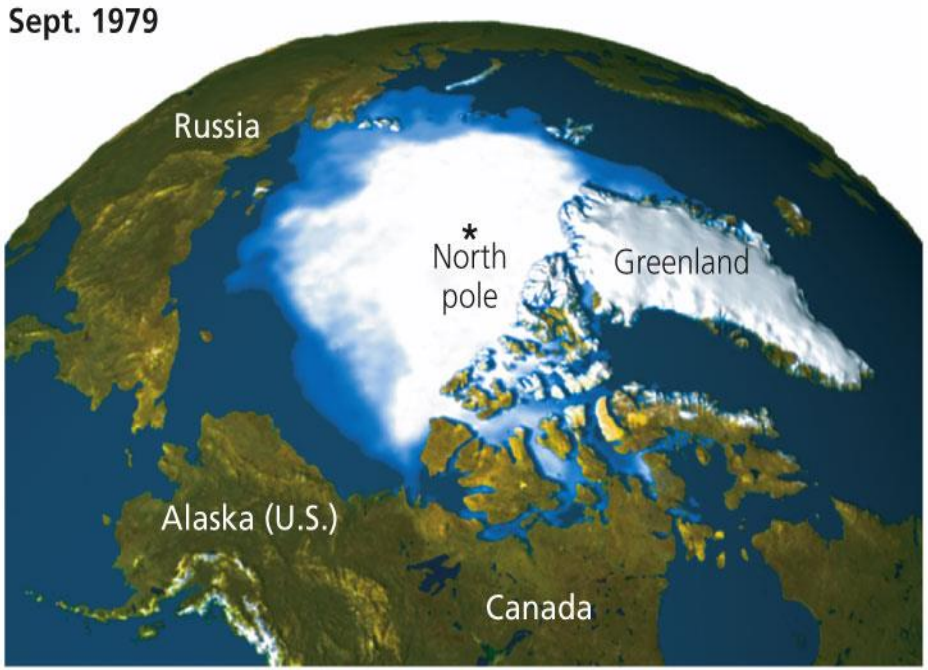
Melting of Alaska's Muir Glacier between 1948 and 2004

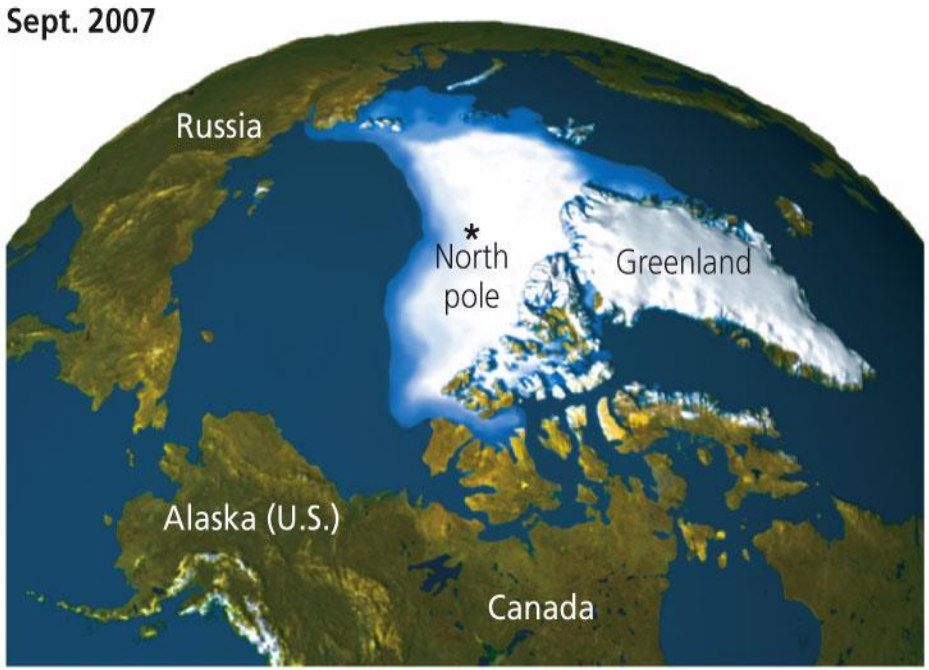
1948

2004

Much of Alaska's Muir Glacier in the popular Glacier Bay National Park and Preserve melted between 1948 and 2004.
Mountain glaciers are now slowly melting throughout much of the world

The Big Melt:
Some of the Floating Sea Ice in the Arctic Sea

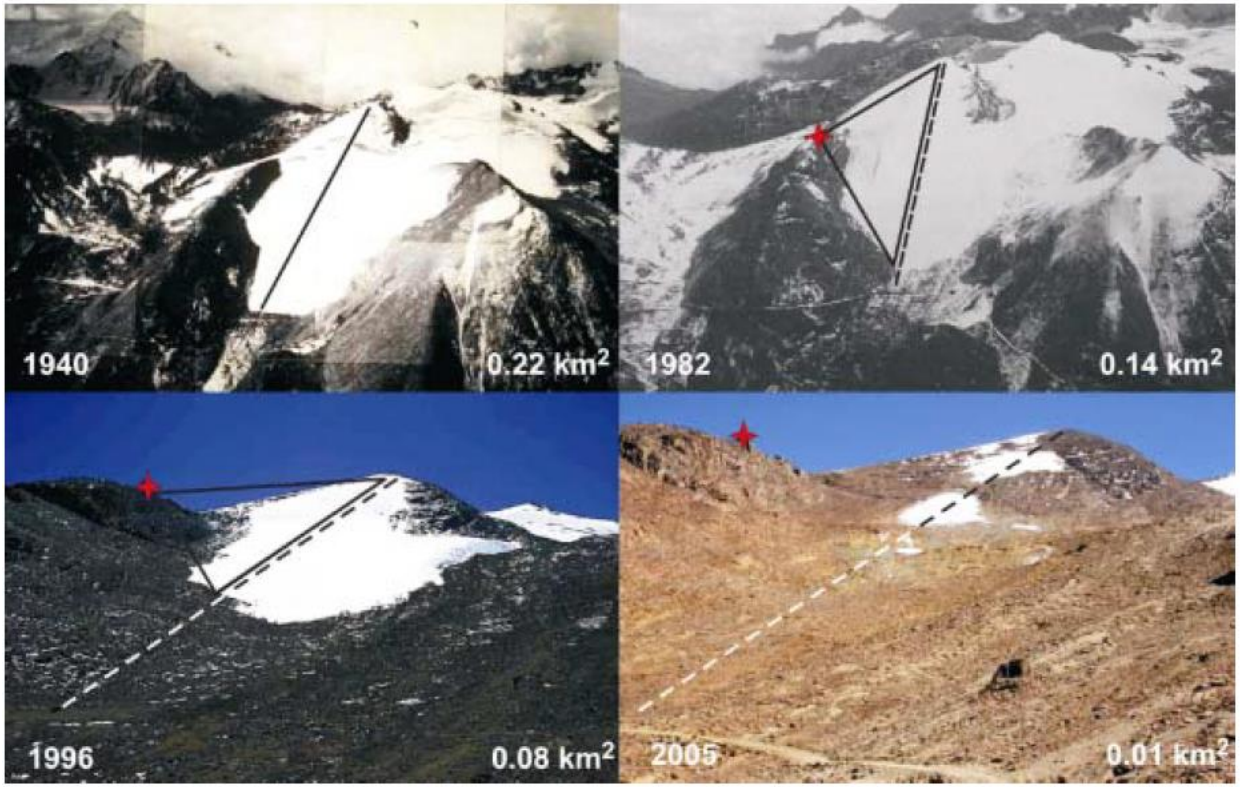




The big melt: Each summer, some of the floating ice in the Arctic Sea melts and then refreezes during winter.

Satellite data show a 39% drop in the average cover of summer arctic sea ice between 1979 and 2007. In 2007 alone, the sea ice shrank by an area that was 6 times that of California, and 240 times larger than lebanon. If this trend continues, this summer ice may be gone by 2040.

Projected Decreases in Arctic Tundra in Russia, 2004-2100



Areal extent of Chacaltaya Glacier, Bolivia, from 1940 to 2005

If the average sea level rises by 1 meter, the areas shown here in red in the U.S. state of Florida will be flooded (Data from Jonathan Overpeck and Jeremy Weiss based on U.S. Geological Survey Data)

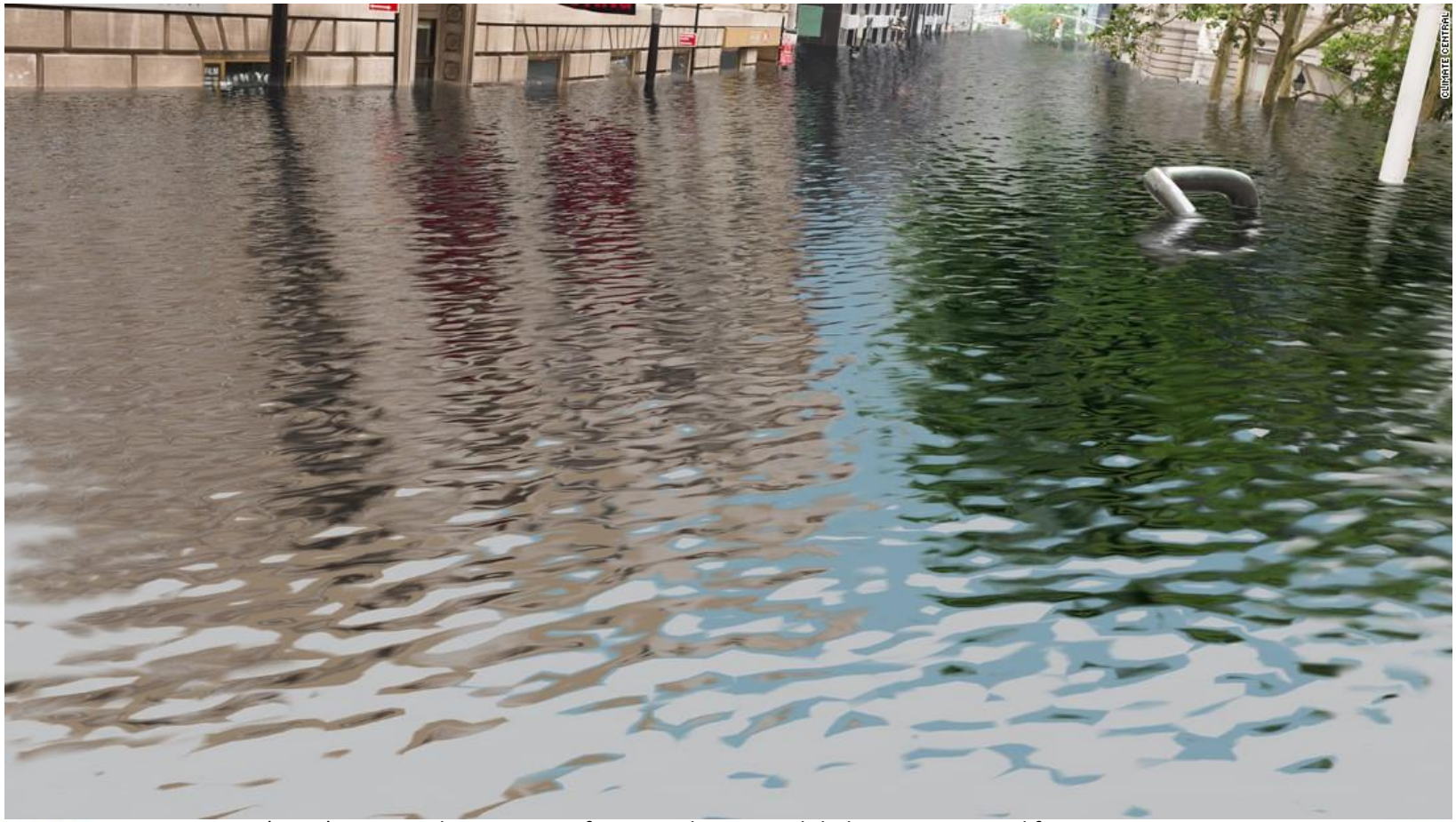
Maldives in the Indian Ocean

- For a low-lying island nation like the Maldives in the Indian Ocean, even a small rise in sea level could spell disaster for most of its 295,000 people.
- About 80% of the 1,192 small islands making up this country lie less than 1 meter above sea level.
- Rising sea levels and higher storm surges during this century could flood most of these islands

New York if the Temperature Increased by 2 Degrees

Strauss, B. (2015). Images Show Impact of Sea Level Rise on Global Icons. Retrieved from: http://www.climatecentral.org/news/global-icons-at-risk-from-sea-level-rise-pictures-19633

New York if the Temperature Increased by 4 Degrees



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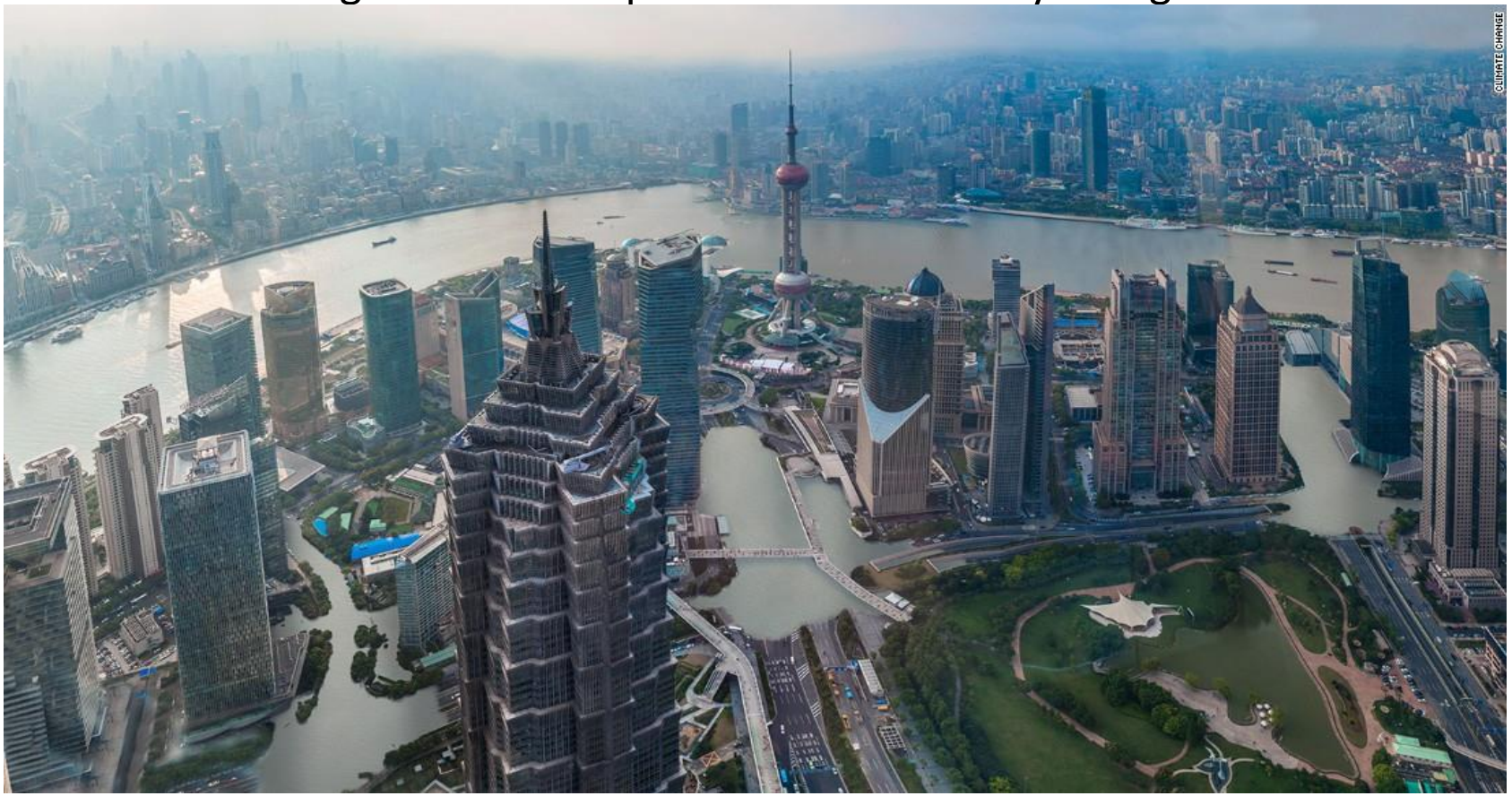
Shanghai if the Temperature Increased by 2 Degrees



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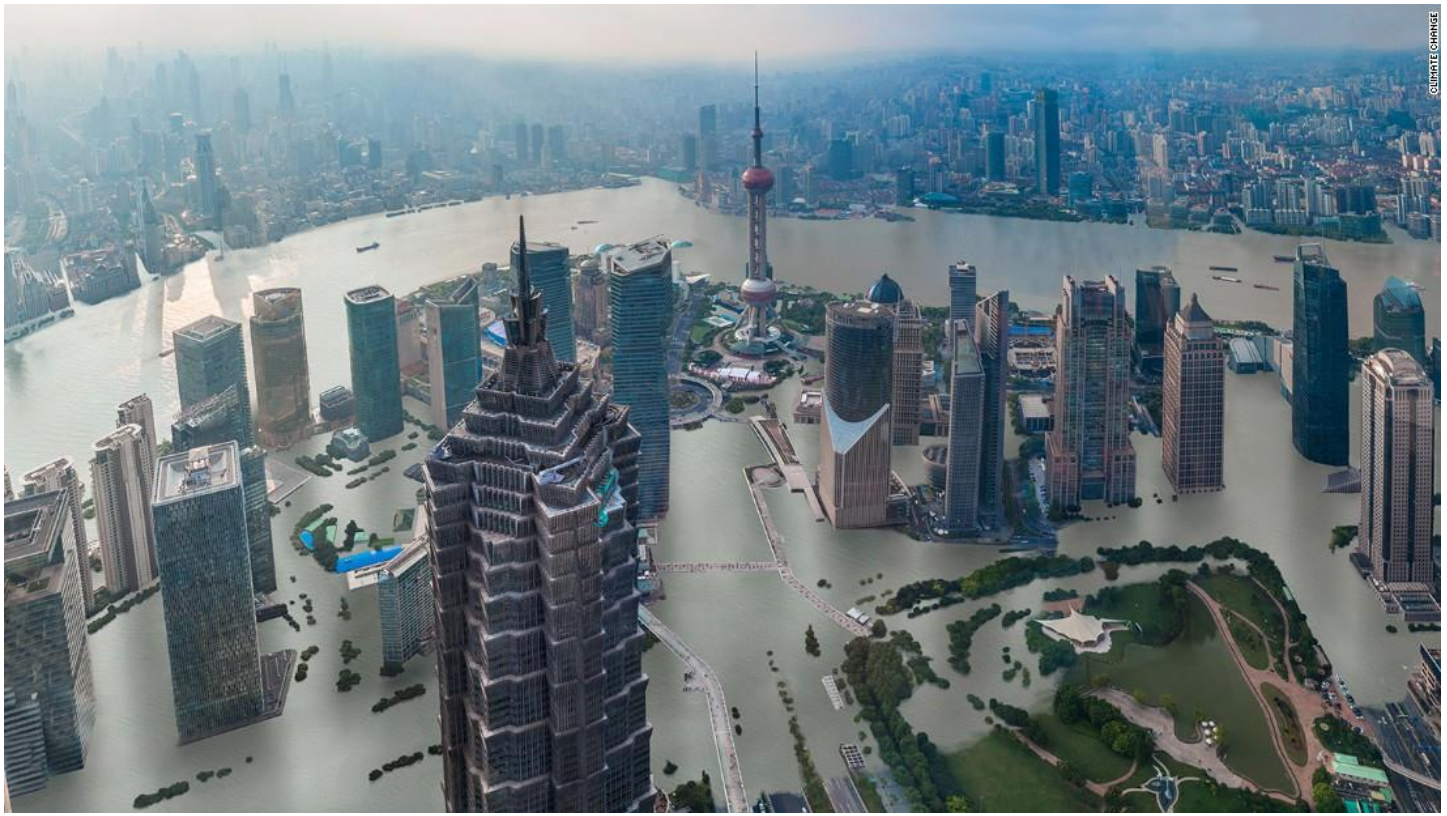

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London if the Temperature Increased by 2 Degrees

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London if the Temperature Increased by 4 Degrees

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Mumbai if the Temperature Increased by 2 Degrees

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Mumbai if the Temperature Increased by 4 Degrees

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Sydney if the Temperature Increased by 2 Degrees

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4. Effects of Global Warming

4. **Effects on Biodiversity:**

- Many terrestrial, freshwater and marine species have shifted their geographic ranges, seasonal activities, migration patterns, abundances and species interactions in response to ongoing climate change.
- Warmer temperature will affect the **distribution and species makeup** of many of the world's ecosystems.
- Species that can adapt to warmer climates → will have expanded range →but this will include some **weeds, pests and disease carrying organisms.**
- Species with specialized niches, narrow tolerance and inability to migrate → **quick extinction.**
- Most plants, small mammals, freshwater molluscs will note be able to adapt.
- Marine organisms will face progressively lower oxygen levels and high rates and magnitudes of ocean acidification.
- Coral reefs and polar ecosystems are highly vulnerable.


JOSEF FRIEDHUBER/GETTY IMAGES/FILE

Golden Toad of Costa Rica has already gone Extinct

5. Effect on Agriculture and Food Stock:

- Climate change will undermine food security.
- Global marine species redistribution & marine biodiversity reduction in sensitive regions will be challenged.
- The rise in temperature (2°C) will negatively impact the production of wheat, maize and rice.
- Farming depends on a stable climate more than anything ➔ Global warming upset this stability by change in → precipitation distribution, water quantities, increase some pests and diseases.
- Climate change impacted the crop yields negatively.
- Hundreds of millions of people could face starvation and malnutrition.

6. Effect on People:

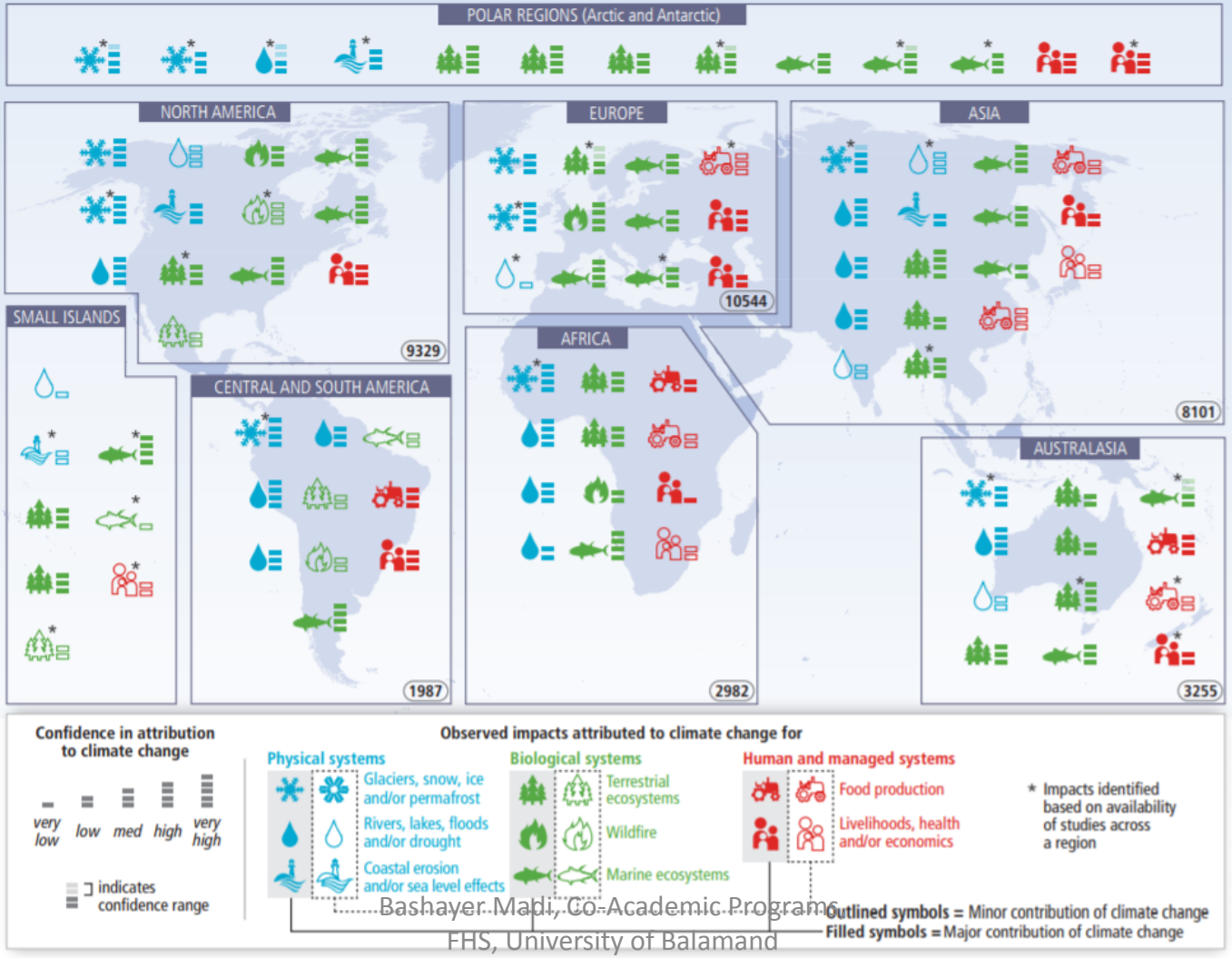
- In urban areas: risks from heat stress, storms and extreme precipitation, inland and coastal flooding, landslides, air pollution, drought, water scarcity, sea level rise and storm surges.
- In rural areas: major impacts on water availability and supply, food security, infrastructure and agricultural incomes, including shifts in the production areas of food and non-food crops around the world.
- Increase deaths from heat (especially among the most vulnerable people) & disruption of food.
- Decrease death from cold.
- Spread of diseases (air pollution, more O_3, more insects, microbes, toxic molds, and fungi).
- Displacement of people: Increase the number of environmental refugees from drought and floods.
- Climate change would slow down economic growth and would result in increase in poverty ➔ increase risk of violent conflicts

7. Effect on freshwater resources

- Changes in precipitation, melting snow and ice → are altering the hydrological systems→ affecting the water resources in terms of quality and quantity.

- Reduction in the renewable surface water and groundwater resources in most dry subtropical regions → competition on water among the different sectors.

Widespread impacts attributed to climate change based on the available scientific literature since the AR4



Drivers to GHGs emissions

Age Structure and Household Size:

- Lower labour force participation and labour productivity ➔ slow economic growth in an ageing society, leading to lower energy consumption and GHG emissions.
- In contrast, another study showed older generations tend to use more energy and emit above average GHGs per person.

Urbanizations:

- Income, energy and lifestyle and GHGs emission differ between urban and rural areas.
- Global urbanization increased from 13 % (1900) to 36 % (1970) to 52 % (2011)
- Factors include: level of development, rate of economic growth, availability of energy resources and technologies, and urban form and infrastructure

Dealing with Climate Disruption Is Difficult

Bashayer Madi, Co-Academic Programs,
FHS, University of Balamand

1. Global problem with long-lasting effects→ require international cooperation.
2. Long-term political problem→ people & officials respond usually well to short term problems.
3. Harmful and beneficial impacts of climate change unevenly spread → there will be winners and losers.
4. Many proposed actions that can phase out fossil fuels are controversial → disrupt economies and lifestyles.
5. Economics, politics and ethics → should the developing countries (the major polluters) take the lead in reducing greenhouse emissions? Are they willing to sacrifice their economies?

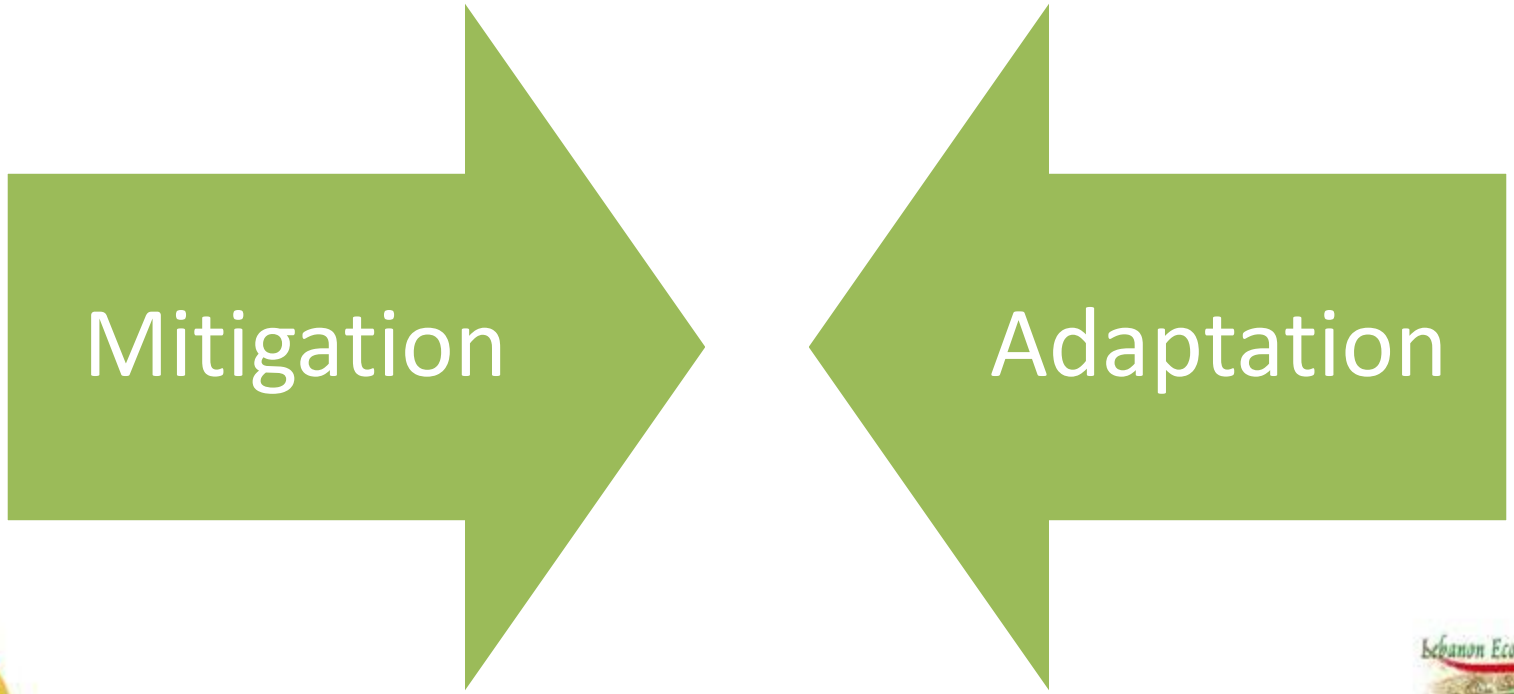
Dealing with Climate Change

Bashayer Madi, Co-Academic Programs,
FHS, University of Balamand

Two approaches include:

1. Mitigation
   - ✓Emission reduction (prevention)
   - ✓Geoengineering (cleanup)
2. Adaptation: reduce the risks of climate change impacts.

Mitigation and adaptation are complementary approaches for reducing risks of climate change impacts over different timescales.

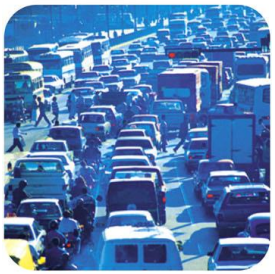


Mitigation

1. Mitigation

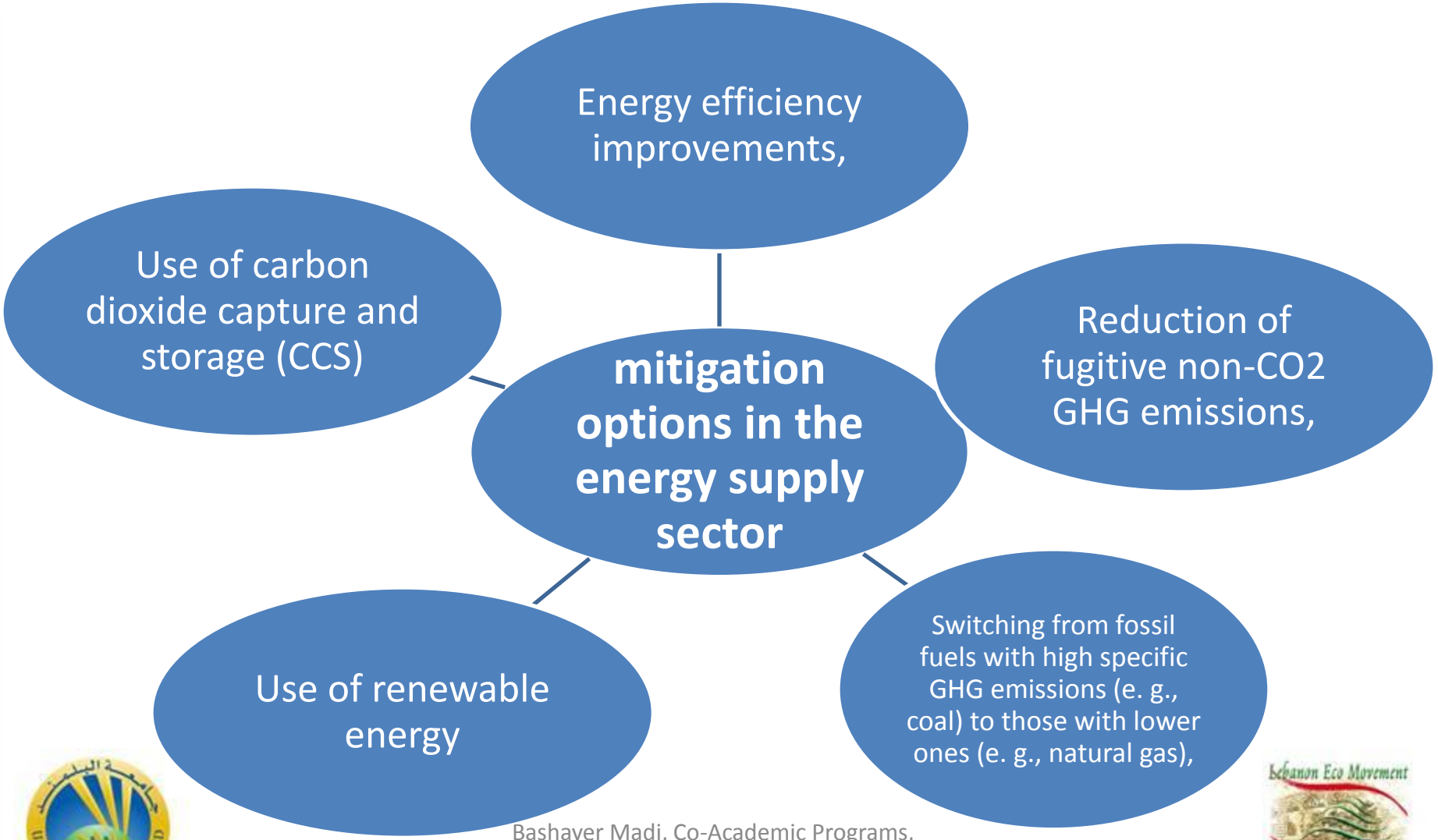
Prevention

- Cut fossil fuel use (especially coal)
- Shift from coal to natural gas
- Improve energy efficiency and conservation (also schools, homes, offices not only industries)
- Shift to renewable energy resources
- Transfer energy efficiency and renewable energy technologies to developing countries
- Prevent deforestation and forest fires
- Rely on sustainable organic farming
- Maintain soil fertility & reduce the use of nitrogen based fertilizers. Add organic fertilizers
- Put a price on greenhouse gas emissions
- Phase out subsidies & introduce CO_2 taxes
- Reduce poverty
- Slow population growth



Cleanup

- Remove CO_2 from smokestack and vehicle emissions
- Store (sequester) CO_2 by planting trees
- Sequester CO_2 in soil by using no-till cultivation and taking cropland out of production
- Sequester CO_2 deep underground (with no leaks allowed)
- Use catalytic convertors in vehicles to reduce N_2O emissions
- Sequester CO_2 in the deep ocean (with no leaks allowed)
- Reduce, reuse and recycle of waste
- Repair leaky natural gas pipelines and facilities
- Use animal feeds that reduce CH_4 emissions from cows (belching)


Energy efficiency improvements,
Use of carbon dioxide capture and storage (CCS)
mitigation options in the energy supply sector
Reduction of fugitive non-CO2 GHG emissions,
Use of renewable energy
Switching from fossil fuels with high specific GHG emissions (e. g., coal) to those with lower ones (e. g., natural gas),

Mitigation options: Transport Sector

Type of transport systems

- Aviation, waterborne transport, rail transport, Road transport (Light duty cars and heavy duty cars)

Lower fuel consumption

- Reducing the loads that the engine must overcome, improved aerodynamic forces, efficient auxiliary components (including lighting and air conditioners), weight reduction and lower rolling resistance tires.

low-carbon transport systems

- Behavioral change and infrastructure investments are often as important as developing more efficient vehicle technologies and using lower-carbon fuels

Mitigation options: Transport Sector (Cont'd)

Avoidance:

- Avoiding unnecessary journeys (for example by tele-commuting and internet shopping).
- Shortening travel distances (densification and mixed-zoning of cities).

Modal choice:

- Shifting transport options to more efficient modes is possible e.g. private cars to public transport, walking, and cycling.
- Can be encouraged by urban planning & the development of a safe and efficient infrastructure.

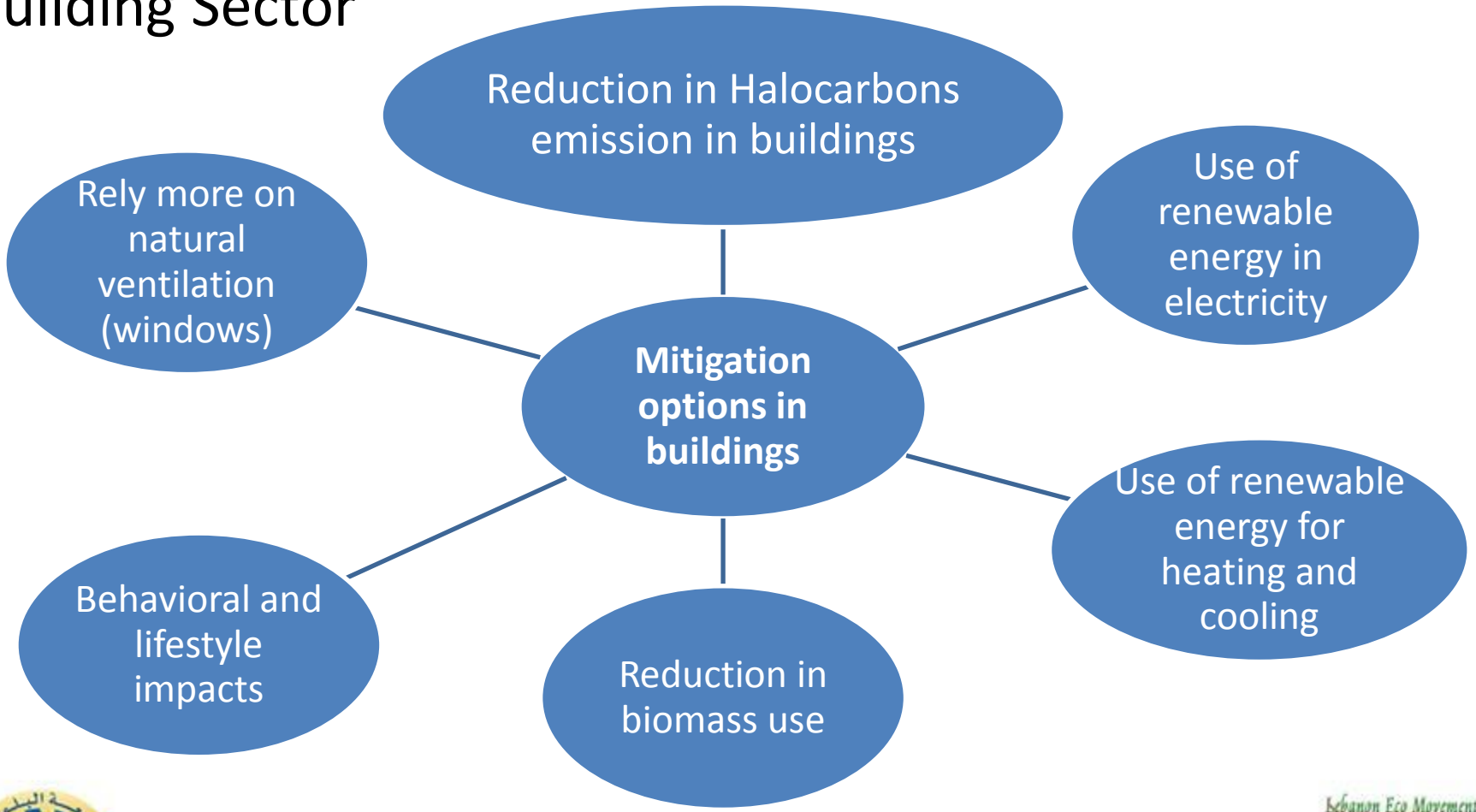
Energy intensity:

- Improving the performance efficiency of aircraft, trains, boats, road vehicles, and engines by manufacturers continues while optimizing operations and logistics (especially for freight movements) can also result in lower fuel demand.

Fuel carbon intensity:

- Switching to lower carbon fuels and energy carriers.
- Using sustainably produced biofuels or electricity and hydrogen when produced using renewable energy or other low-carbon technologies.

Building Sector



Mitigation options: Industry Sector

Energy efficiency

Material efficiency (through reduced yield losses in production, “reduce, re-use, recycle”)

re-use of materials and recycling of products

Waste prevention and minimization in the production design, utility and disposal of their products

More intensive and longer use of products

Reduced demand for product services

Emissions efficiency (including fuel and feedstock switching, carbon dioxide capture and storage)

replacement of concrete and steel in buildings with wood, some bioenergy options

Mitigation options: Waste Sector

Reduction	Reuse and recycling	Landfilling and methane capture from landfills
Landfill aeration	Anaerobic digestion of solid waste produces methane	mechanical-biological treatment of MSW

Mitigation options: wastewater

Methane can be captured from anaerobic digestion of sludge ➔energy source

Membrane filtration, ozonation, aeration efficiency, etc.

Mitigation options: Agriculture, Forestry and Other Land Use

Reductions in CH_4 or N_2O emissions from croplands, grazing lands, and livestock.

Conservation of existing carbon stocks, e. g., conservation of forest biomass, peatlands, and soil carbon that would otherwise be lost.

carbon sequestration in soils and vegetation

Mitigation options: Agriculture, Forestry and Other Land Use

Reductions of carbon losses from biota and soils, e. g., through management changes within the same land-use type (e. g., reducing soil carbon loss by switching from tillage to no-till cropping) or by reducing losses of carbon-rich ecosystems, e. g., reduced deforestation, rewetting of drained peatlands.

Reductions of direct (e. g., agricultural machinery, pumps, fishing craft) or indirect (e. g., production of fertilizers, emissions resulting from fossil energy use in agriculture, fisheries, aquaculture, and forestry or from production of inputs)

Mitigation options: Agriculture, Forestry and Other Land Use (Cont'd)

- Enhancement of carbon sequestration in soils, biota, and long-lived products through increases in the area of carbon-rich ecosystems such as forests (afforestation, reforestation)
- Increased carbon storage per unit area, e. g., increased stocking density in forests, carbon sequestration in soils, and wood use in construction activities.
- Changes in albedo resulting from land-use and land-cover change that increase reflection of visible light.
- Fire management
- Improved livestock breeds and diets

Mitigation options: Agriculture, Forestry and Other Land Use (Cont'd)

Soil conservation: involves using a variety of ways to reduce soil erosion and restore soil fertility, mostly by keeping the soil covered with vegetation.

Four methods:

1. Terracing
2. Contour planting
3. Strip cropping
4. Alley cropping or agroforestry
5. Windbreaks
6. Conservation-tillage

(a) Terracing

(b) Contour planting and strip cropping

(c) Alley cropping

(d) Windbreaks

Mitigation options: Agriculture, Forestry and Other Land Use (Cont'd)

Adding organic fertilizers to maintain soil fertility:

It includes three types:

1. **Animal manure:** the dung and urine of cattle, horses, poultry and other farm animals:
   - → it improves soil structure
   - → adds organic nitrogen
   - → stimulates beneficial bacteria and fungi

2. **Green manure:** freshly cut or growing green vegetation that is plowed into the topsoil to **increase the organic matter & humus** available to the next crop

3. **Compost:** natural fertilizers/conditioners produced when microorganisms in soil break down organic matter (leaves, crop residues, food waste, paper, and wood) in the presence of oxygen

4. **Practicing crop rotation:**

→ planting a field or an area of a field with different crops from year to year →to reduce soil nutrient depletion.

→ **Example:** planting corn and cotton (removes nitrogen from soil) one year and planting a legume such as soybeans (adds nitrogen to the soil) the next year

➔ This method adds nutrients and reduce soil erosion→ soil covered with vegetation

Mitigation options: Agriculture, Forestry and Other Land Use (Cont'd)

Relying on Sustainable organic farming:

→ Crops are grown with **little or no use** of synthetic pesticides, synthetic fertilizers, or genetically engineered seeds.

→ Also livestock are raised **without use** of genetic engineering, synthetic growth regulators or feed additives.

→ Fields must be free of chemicals for **3 years before** crops are grown.

Solutions Organic Farming

- Improves soil fertility
- Reduces soil erosion
- Retains more water in soil during drought years
- Uses about 30% less energy per unit of yield
- Lowers CO_2 emissions
- Reduces water pollution by recycling livestock wastes
- Eliminates pollution from pesticides
- Increases biodiversity above and below ground
- Benefits wildlife such as birds and bats

Adaptation

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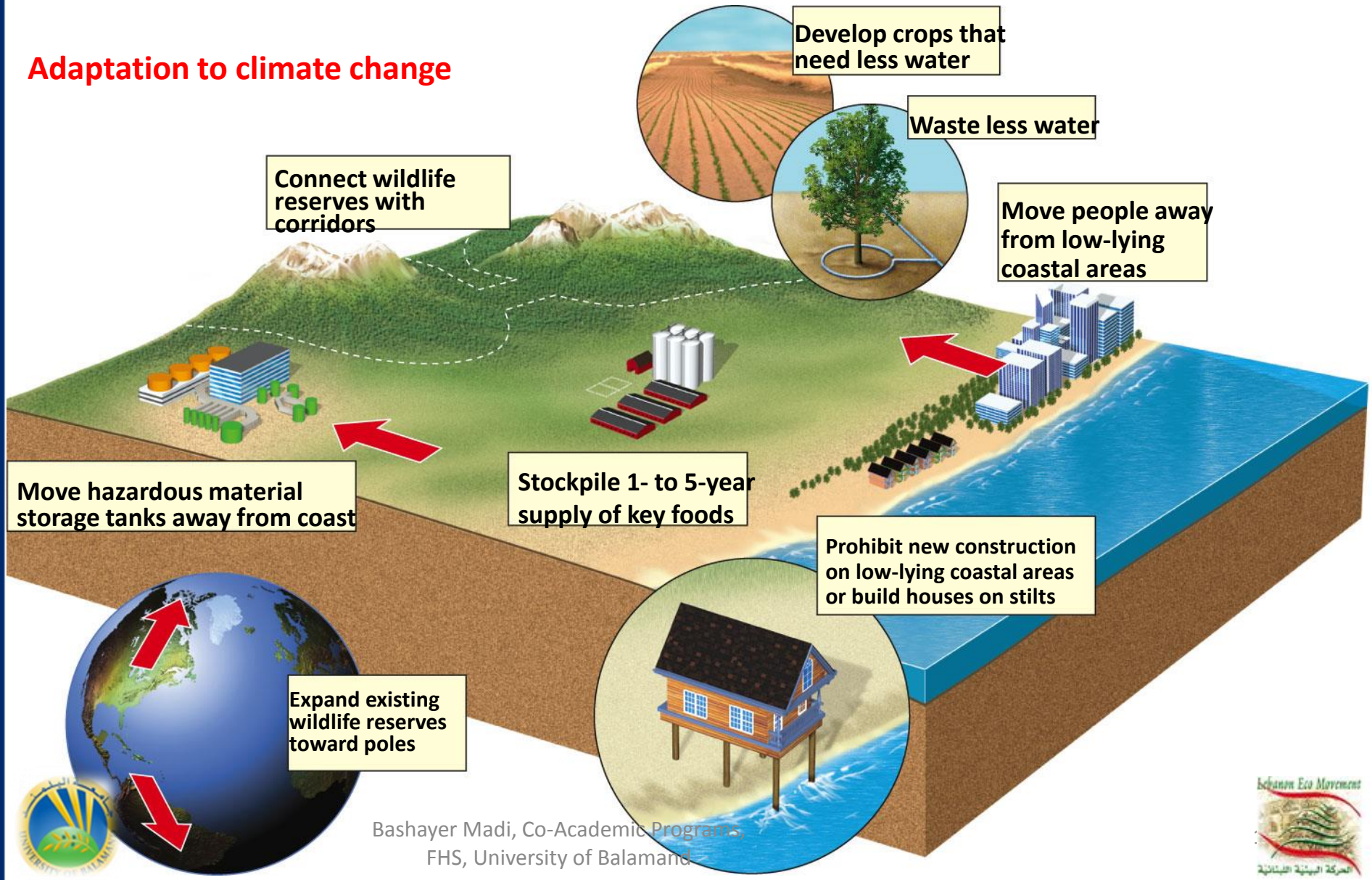
Adaptation to climate change



Solutions to Climate Change

2. Adaptation to climate change:

the damage already caused may increase Earth's temp. by 0.5 - 1.8 °C.

- Breed plants that need less water.
- Build dikes to protect coastal areas.
- Move storage tanks of hazardous chemicals inland.
- Ban new construction on low-lying coastal areas.
- Stockpile food as short-term emergency measure.
- Connect wildlife with corridors allowing giving them mobility.
- Waste less water.

Adaptation to climate change:

Agricultural practices:

- ✓ Changing crop location (higher elevation environments and cooler micro-climates)
- ✓ Changing crop rotation patterns and tilling methods → keeps sub surface soil coolers and wetter → lessen the effect of warmer and dryer conditions
- ✓ Crop varieties → better adapted to changing climate conditions
- ✓ Change the choice of grown crop

International Climate Negotiations

Bashayer Madi, Co-Academic Programs,
FHS, University of Balamand

- **Convention:** a written treaty or agreement between states (nations) that regulates matters of common concern, thus becoming a part of international law.

- **Protocol:** An international agreement that usually complements or expands upon an existing treaty or agreement.

- **Signature:** the endorsement of an authorized government representative at a diplomatic conference indicates the support of an agreement. A signatory is a party who sign a treaty or agreement.

- **Ratification:** an act of government that legally binds the nation to a treaty already signed by that government's representative.

- **Accession:** the act by which one state obligates itself to a treaty already in force between other states .

United Nations Framework Convention on Climate Change (UNFCCC)

- It is "Rio Convention", adopted at the "Rio Earth Summit" in 1992. It entered into force on 21 March 1994

- *UNFCCC:" stabilization of greenhouse gases concentration in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system"*

- **Kyoto Protocol:** 1997: Treaty to slow climate change and entered into force in 2005
  - It operationalizes the convention
  - commits its parties to adopt/set binding international emission reduction targets of greenhouse gases
  - Encourages cleaner production
  - It sets out the goals of reducing emission of the greenhouse gases

Refer to: http://www.youtube.com/watch?v=jzSuP_TMFtk

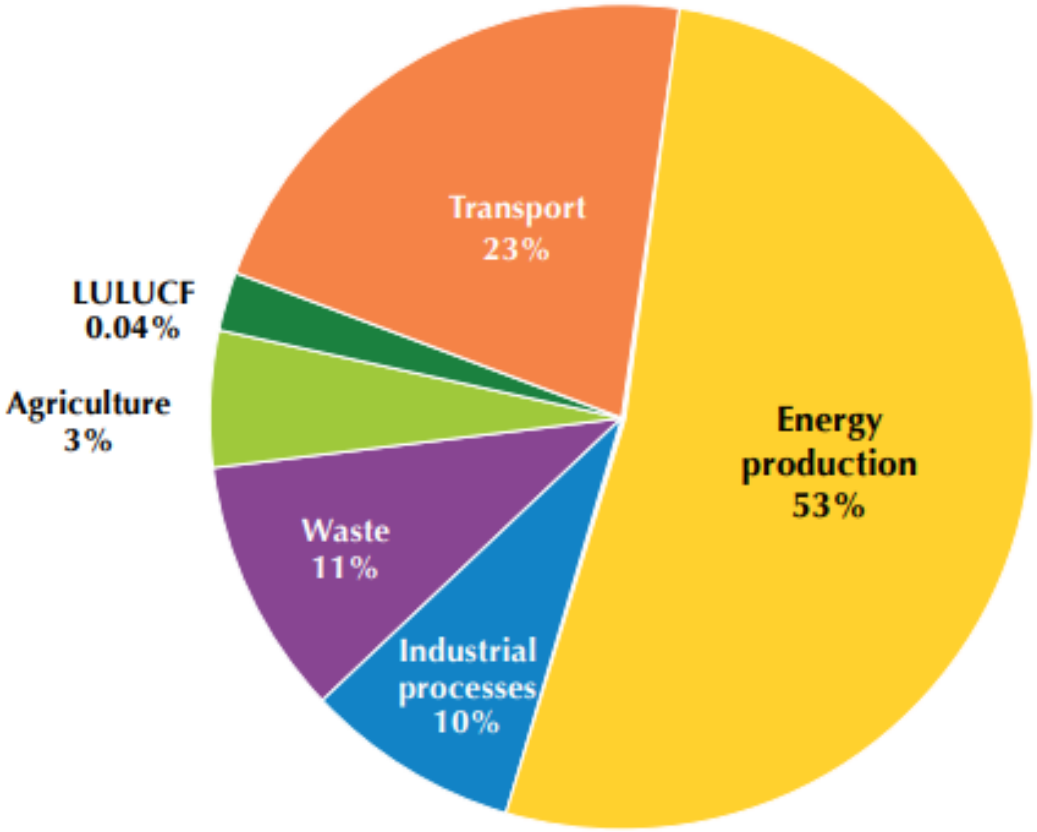
Paris Agreement in 2015:

- latest evolution of the UNFCCC
- Paris Agreement entered into force in 2016
- “Its main objective is to strengthen the global response on climate change and hold global average temperature at 2°C and further decrease it to 1.5°C”

Lebanon

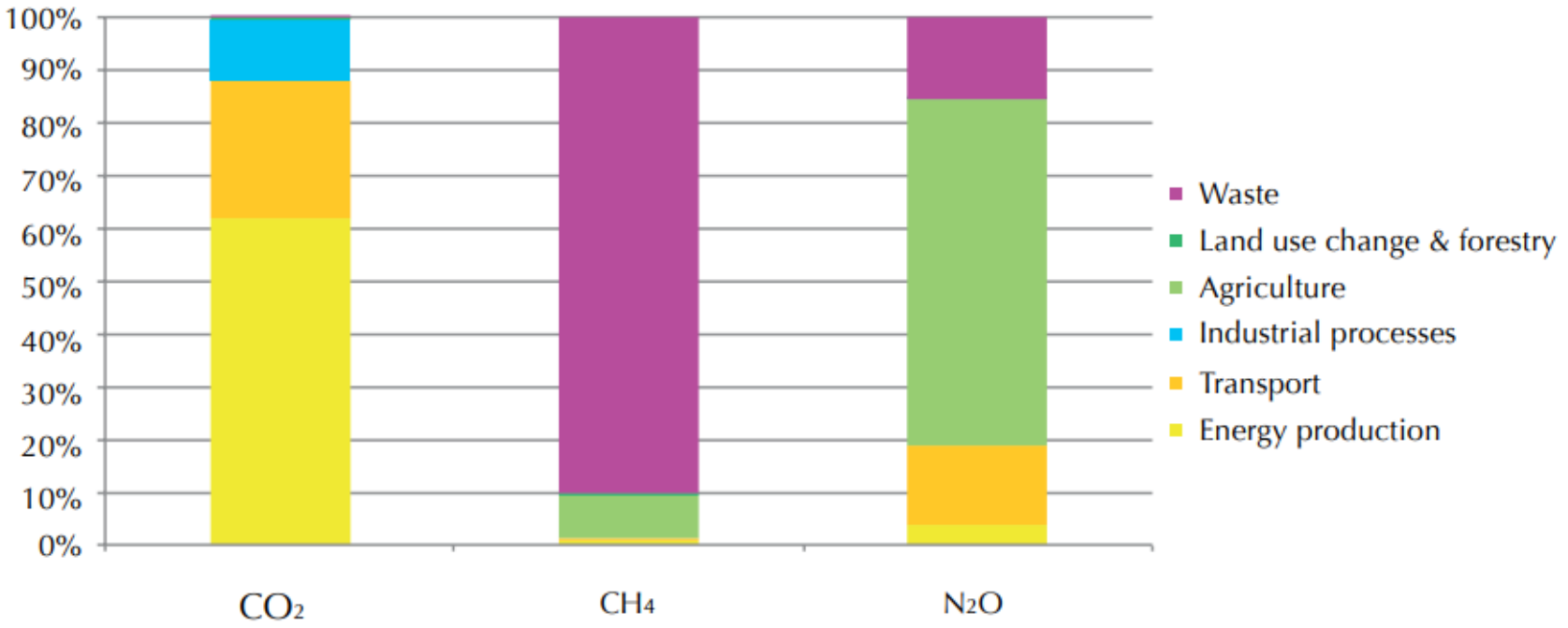
Bashayer Madi, Co-Academic Programs,
FHS, University of Balamand

Lebanon Emissions by sector in 2012



MoE/UNDP/GEF (2016). Lebanon's third national communication to the UNFCCC. Beirut, Lebanon

Lebanon GHGS emissions by sector in 2012



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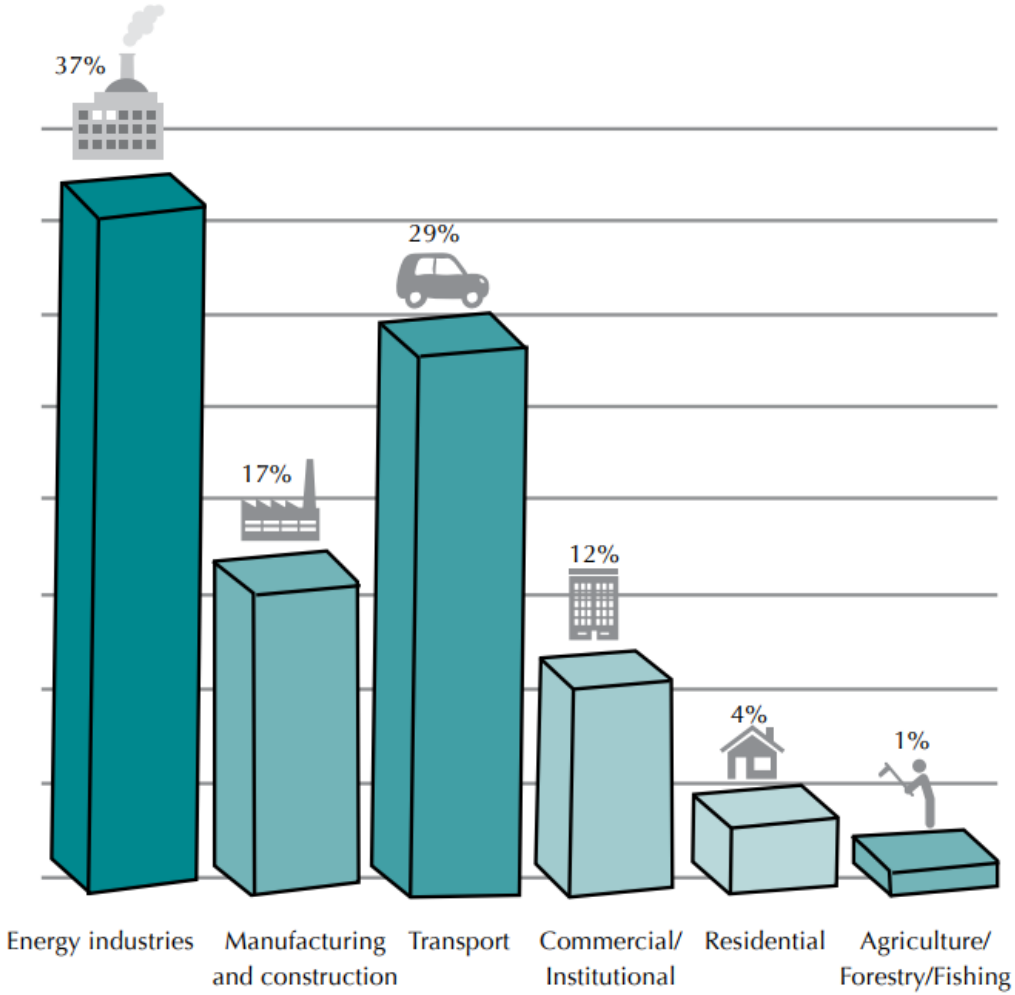
Lebanon: Contribution of energy emission sources to the sector's total for 2012



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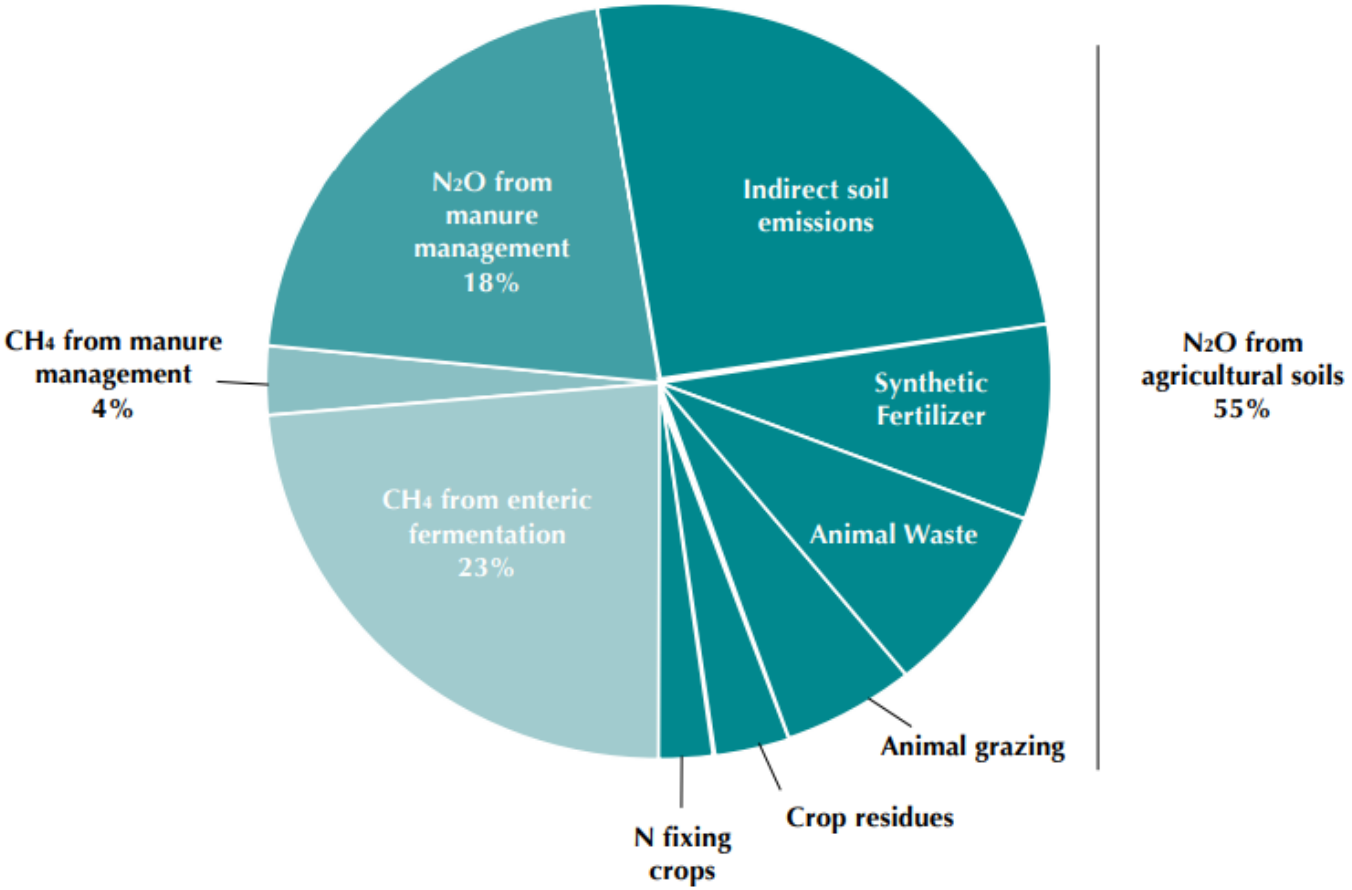
Sources of GHG emissions from the agricultural sector in Lebanon



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The Republic of Lebanon ratified the UNFCCC in 1994 with Law No. 359 as a Non-Annex I Party.

The Kyoto Protocol was ratified by in 2006 with Law No. 738. Lebanon signed the Paris Agreement in April 2016.

The Ministry of Environment (MoE) is the focal point to the UNFCCC and the Lebanese delegation has been participating in international climate change talks since 2006.

Lebanon submitted its climate pledge under the UN framework on climate change ahead of Paris Agreement: Intended Nationally Determined Contribution

- Prime Minister on April 2016, signed the new Climate Change Paris Agreement.

The Intended Nationally Determined Contribution, includes:

- 15 % reduction in GHGs emissions (30%)
- 15% of power & heating demand should be from renewable energy by 2030 (20%)
- Increase energy efficiency by 3% (10%)
- Increase share of public transportation by 36%-48%
- Planting trees

Energy sector:

- A policy paper on the energy sector was issued in 2010
- Renewable energy sources
- Shifting electrically driven hot water systems to renewable energy/solar thermal systems;
- Producing electricity through renewable resources such as solar, wind, geothermal, biomass, and hydro;
- Upgrade of the transmission and distribution infrastructure including one for natural gas,
- Establishment of a smart grid,
- Development of demand side management and energy efficiency as well as tariff restructuring

Transport sector:

- Replacement of old and inefficient vehicles gradually with fuel efficient vehicles.
- Increasing the share of small passenger vehicles to 35% and decreasing the share of large vehicles to 10% renews the vehicle fleet with a more energy-efficient one.
- Introducing hybrid electric vehicles in the market to reach a share of 10% by 2040.
- Restructuring and modernizing the bus transport system in the Greater Beirut Area.

Agriculture Sector:

- Efficient management of resources: water, fertilizers, seeds and fuel.
- Conservation agriculture and fertigation to a limited crop type and harvest area.
- Adoption of more drought and heat-resistant species, change planting dates and cropping patterns.

Landuse and Land use change forestry

- Protecting existing carbon reservoirs from losses associated with deforestation, forest and land degradation and urbanization.
- Enhancing carbon sequestration through reforestation, afforestation, and forest management.
- Reducing emissions from fire management.

Waste sector:

- Increasing the rate of wastewater collection & treatment.
- Decreasing discharges in septic tanks and in surface waters.
- Replace landfilling and open dumping with *proper solid waste management option.*


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act now before it's too late
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Bashayer Madi, Co-Academic Programs,
FHS, University of Balamand

Lebanon Eco Movement