Climate Change and Sustainable Agriculture

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Concept

Climate change means any significant change in climate, like temperature or rainfall, over a 30 year period or more. If the climate is changing, then the 30 year average temperature, or rainfall, or number of sunny days, is changing.

It's easy to mix up climate and weather.

- 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
- The world's climate has been getting warmer since 1900. However, this overall warming has not occurred evenly across the world's surface and different places, because of their location and geography, are affected in different ways.

Pattern of atmospheric change

- During the last century, the atmospheric concentration of greenhouse gases and their radiative forcing have continued to rise as a result of human activities.
- Global average surface temperatures have increased by about 0.6°C.
- Global average sea level has risen and ocean heat content has increased.
- "The balance of evidence suggests a discernable human influence on global climate" (IPCC, 1995)
- "There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities" (IPCC, 2001)
- CO_2 Concentrations and Global Average Temperatures Will Continue to Rise

In terms of climate change, 3 important components of climate changed viz.

- Temperature Change
- Precipitation Change
- Sea Level Rise

Causes of Climate change

Natural

- Explosions on the sun ("sun spots")
- Changes in earth's orientation toward the sun
- Changes in the amount of energy coming from the Sun
- Volcanic eruptions on a massive scale
- Explosions caused by large meteors hitting the earth

Man made

- Greenhouse effect

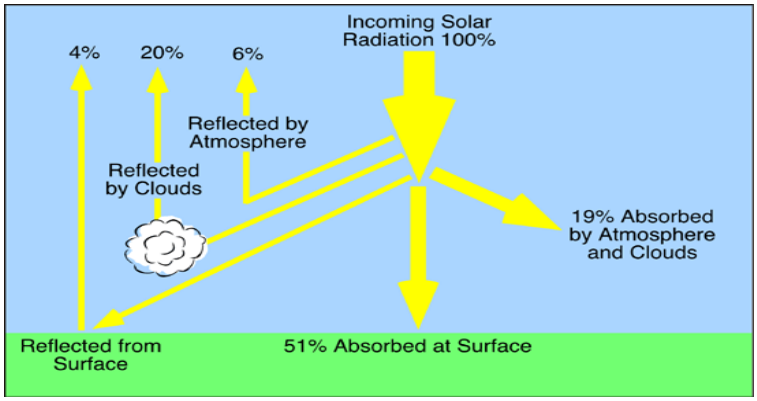
Explosions on the sun ("sun spots")

In the earlier ties Explosions on the sun ("sun spots") caused great changes in the climate.

Changes in earth's orientation toward the sun

Changes in the energy output of the Sun, and the Earth's orbit around the Sun, do have an effect on the Earth's climate. Ice ages have come and gone in regular cycles for nearly three million years. There is strong evidence that these are linked to regular variations in the Earth's orbit around the Sun, the so-called Milankovitch cycles. These cycles change the amount of the Sun's energy received by different places on the Earth's surface.

Changes in the amount of energy coming from the Sun



Volcanic eruptions on a massive scale

There were 3 volcanic eruptions big enough to affect the climate in the 20th century – Agung in Indonesia (1963), El Chichon in Mexico (1982) and Pinatubo in the Philippines (1991). Material (particles) from violent volcanic eruptions can be projected far above the highest cloud, and into the stratosphere where they can significantly increase how much incoming solar energy is reflected. Major volcanic eruptions can reduce average global surface temperature by about 0.5°C for months or even years.

Collisions with comets or meteorites

The Earth's atmosphere protects us from the impacts of comets and meteorites, by vaporizing all or most of the incoming material before reaching the Earth's surface. Scientists believe however, that every once in a while a celestial body of significant size collides with the Earth, causing untold destruction and an ensuing global climate change.

The comet/meteorite impact theory of climate change has been considered to account for the extinction of the dinosaurs 65 million years ago.

Green house gases

In the first half of the 20th century global temperatures have risen because of increases in the levels of greenhouse gases in the atmosphere as well as changes in the amount of energy emitted by the Sun. In the second half of the 20th century warming is mainly due to changing greenhouse gas concentrations.

Greenhouse effect

It is essential to human life! The natural greenhouse gas effect keeps Earth much warmer than it would otherwise be. Without the greenhouse effect, planet Earth would be too cold to support human life as we know it.

The temperature of the Earth is determined by the balance between energy coming in from the Sun in the form of visible radiation (sunlight) and energy constantly being emitted from the surface of the Earth to outer space in the form of invisible infrared radiation (heat).

The energy coming in from the Sun can pass through the clear atmosphere pretty much unchanged and therefore heat the surface of the Earth. But the infrared radiation emanating from the surface of the Earth is partly absorbed by some gases in the atmosphere, and some of it is re-emitted downwards. The effect of this is to warm the surface of the Earth and lower part of the atmosphere. This is called the greenhouse effect.

The absorbing gases in the atmosphere are primarily water vapor (responsible for about two-thirds of the effect) and carbon dioxide. Methane, nitrous oxide, ozone and several other gases present in the atmosphere in small amounts also contribute to the greenhouse effect. Without the greenhouse effect the Earth would be, on average, about 33°C colder than it presently is.

Naturally occurring gases in our atmosphere, such as carbon dioxide and methane, provide an insulating effect without which the earth would be a frozen planet. However, levels of greenhouses gases in the atmosphere have increased, preventing more heat escaping to Space and leading to 'global warming'.

Over the past 150 years in the industrial era, human activities have increased the emissions of three principal green house gases: carbon dioxide, methane and nitrous oxide. These gases accumulate in the atmosphere, causing concentrations to increase with time.

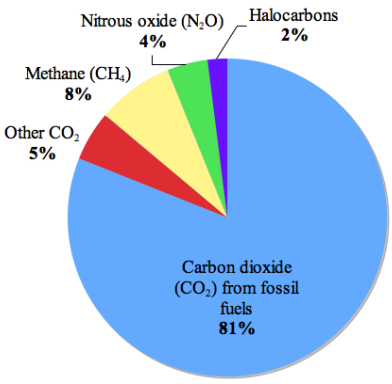
Carbon dioxide (CO_2) has increased from our use of fossil fuels which we burn for use in transpor tation, energy generation, building heating and cooling. Deforestation also releases CO_2 and reduces its uptake by plants.

Methane (CH_4) has more than doubled as a result of human activities related to agriculture, natural gas distribution and landfills. However, increases in methane concentrations are slowing down because the growth of emissions has decreased over the last two decades.

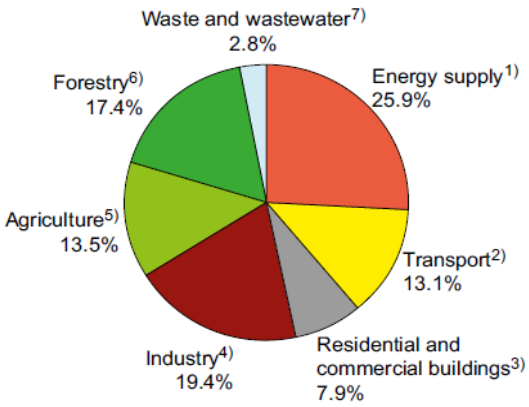
Nitrous oxide (N_2O) is also emitted by human activities such as fertil izer use and fossil fuel burning. There are other, lesser, contributors such as CFCs (whose emissions have decreased substantially) and ozone in the lower atmosphere.

Water vapour is the most abundant and important greenhouse gas in the atmosphere. However, human activities have only a small direct influence on the amount of atmospheric wa ter vapour. Indirectly, humans have the potential to affect water vapour substantially by changing climate as a warmer atmosphere contains more water vapour.

Relative proportion of anthropogenic greenhouse gases (2007)



GHGs emission by sector (2004)



Scenario of CO_2 emission

Around 4% of world's total population are in USA who emmit 25% of the world's greenhouse gases. In contrast, China, where 25% of the world's population lives emits 8.5% of the world's greenhouse gases.

Effects of climate change

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.

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 worming

Rise in temperature

- Global mean temperatures are rising faster with time
- 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
- 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

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

Rise in sea level

- 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
- There many problems arising due to sea level rise, Such as -

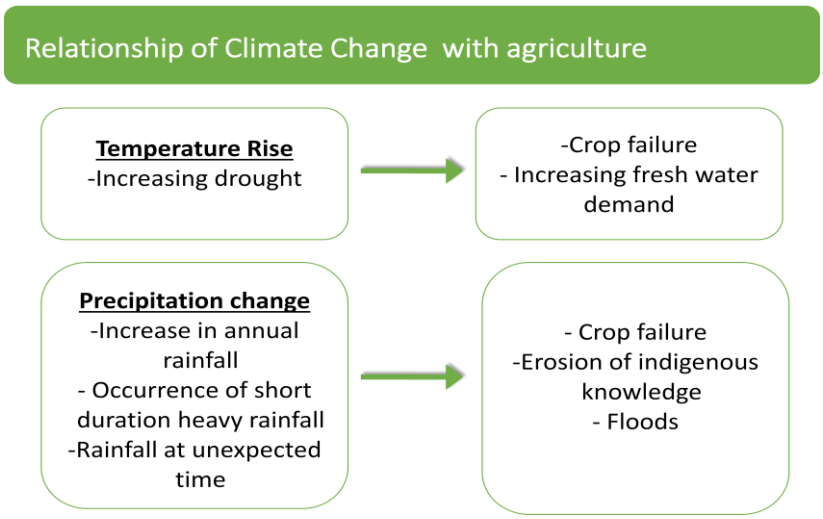
    - Beach erosion,
    - Flooding,
- Intrusion of salt water into aquifers
- Loss of wetlands (mangroves)
- Loss of coral reefs
    - Bangladesh, Maldives
- Possible evacuations and migration of people
    - Island nations of Maldives

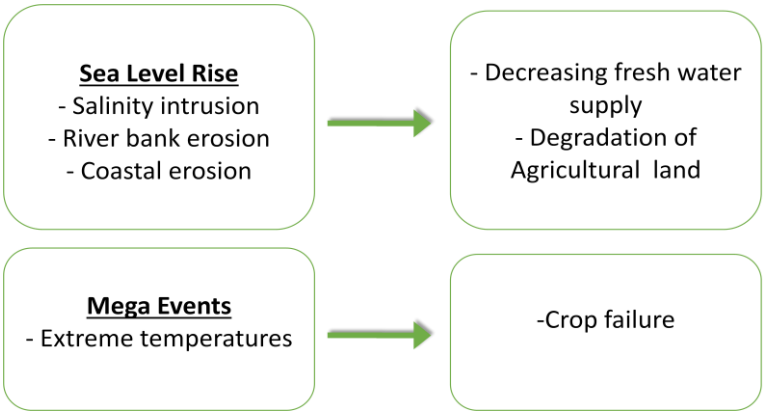
Predicted effects of climate change on agriculture over the next 50 years

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°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

Current projections, from the 4th Assessment report by the Intergovernmental Panel on Climate Change (IPCC) published in 2007, suggest that global temperatures will rise between 1.8^{o}C and 4.0^{o}C (best estimate) by 2100 depending on emissions of greenhouse gases and that global sea levels are likely to rise from anywhere between 180 mm and 590 mm.

Climate change its effect agriculture





The major impacts of climate change on agriculture are -

- 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

Soil processes

The potential for soils to support agriculture and distribution of land use will be influenced by changes in soil water balance:

- Increase in soil water deficits i.e. dry soils become drier, therefore increased need for irrigation but:
- Could improve soil workability in wetter regions and diminish poaching and erosion risk
- Higher temperatures and, higher rainfall levels, will accelerate soil organic matter break down
- Low organic matter soils hold few nutrients and are more susceptible to drought
- Soil erosion will be higher

Crops

The effect of increased temperature and CO_2 levels on arable crops will be broadly neutral:

- The range of current crops will move northward
- New crop varieties may need to be selected
- Horticultural crops are more susceptible to changing conditions than arable crops
- Field vegetables will be particularly affected by temperature changes
- Bean, onion and sweet corn are most likely to benefit commercially from higher temperatures
- Water deficits will directly affect fruit and vegetable production

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.

Pests resurgence

- Weeds, diseases, insects will spread from warmer areas into formerly cooler ones.
- Warmer winters allow overwintering of larvae in areas where this was not possible.
- Increased number of generations possible.
- Longer time for development and feeding and a wider range of pests.

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.

Increased use of Pesticides

- There will be a greater need for applications of various pesticides
- Genetically modified crops may help out in this area

Changes in farming practices and declines in biodiversity

- Concentration on winter crops with a consequent loss of spring crops,
- Increased farm specialization with a decline in livestock and grass enterprises in arable areas
- Changes in cultivation dates
- Loss of semi-natural habitat in farmland, including field margins.

Intensified upland grazing management

- Changes in land management are the main cause of environmental degradation
- Increased stocking densities on upland grazing resulting in sward damage and reduction or loss of species
- Intrusion of farming activities disturbing plant and wildlife, domestication of landscape (i.e. feed troughs, hardcore tracks etc.)
- Increased competition for grazing between domestic and wild species.

Pesticide & fertilizer drift

Accidental spray drift into hedge bottoms is very common, particularly in arable fields that are cultivated right up to the field boundary. The removal of hedge base flora has been shown to reduce insect numbers, having an indirect effect on predatory invertebrates, bird, mammal and where relevant, reptile and amphibian populations. The same factors apply to the use of insecticides, many of which are 'broad spectrum' and consequently lethal to a diverse range of invertebrates.

Changes in species

Changes in arable farming practices have been identified as important factors in the decline of wildlife.

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)

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

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 3-4ºC higher seasonal maximum sea-surface temperatures for 6 months or more
- Substantial reduction in glacier and ice-cap volume; tropical glaciers particularly vulnerable to elimination
- Loss of unique vegetation systems and their endemic species (e.g. vegetation of Cape region of South Africa and some cloud forests)
- 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

Potential positive effects of climate change

- 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

Climate Change and Bangladesh

Key facts

- Bangladesh-most vulnerable countries of the world.
- Negligible gas emissions - worst victim.
- Bangladesh emits a minuscule of green house gases.
- in 2005 terms,- 0.053 to 0.045 billion tonnes
- Developed countries -18.2 billion tonnes in 2005.

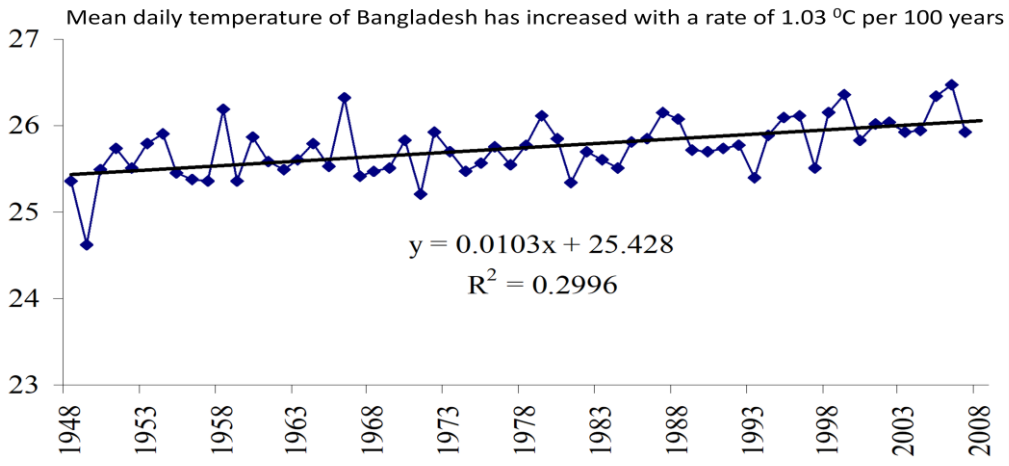
Why Bangladesh is vulnerable?

Bangladesh is one of the most vulnerable countries because of its

- geographic location;
- flat and low-lying topography;
- high population density;
- reliance of many livelihoods on climate sensitive sectors, particularly agriculture and fisheries

Climate Change Impacts: Bangladesh

- Cyclone/storm surge: increased frequency, intensity, increasing salinity
- Floods: increased frequency, magnitudes
- Droughts: Spreading over time and space
- Erratic rainfall: Intensive rain in short time
- Temperature: extremes increasing
- Riverbank and coastal erosion: increasing
- Water logging and permanent inundation due to sea level rise



Temperature Rise

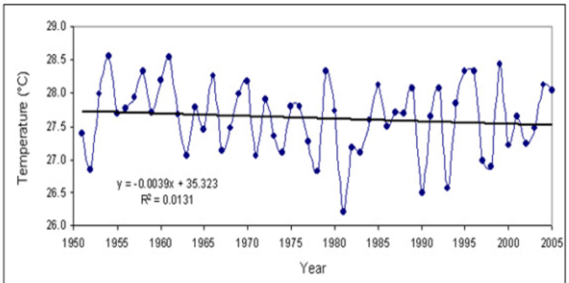


Fig. 4.11: Trend of mean temperature (°C) in Bangladesh during Pre-monsoon season

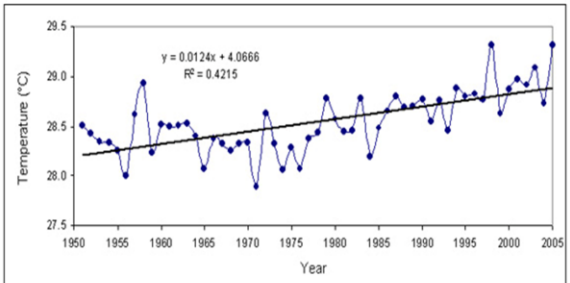


Fig. 4.12: Trend of mean temperature (°C) in Bangladesh during Monsoon season

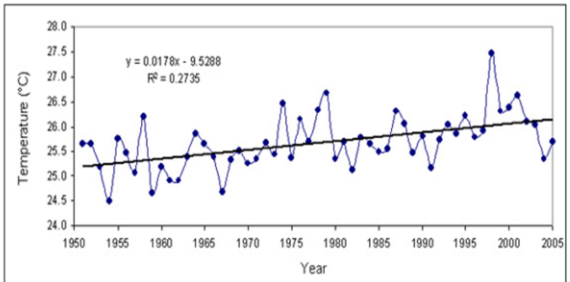


Fig. 4.13: Trend of mean temperature (°C) in Bangladesh during Post-monsoon season

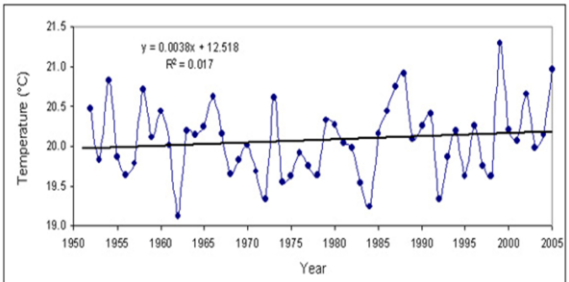
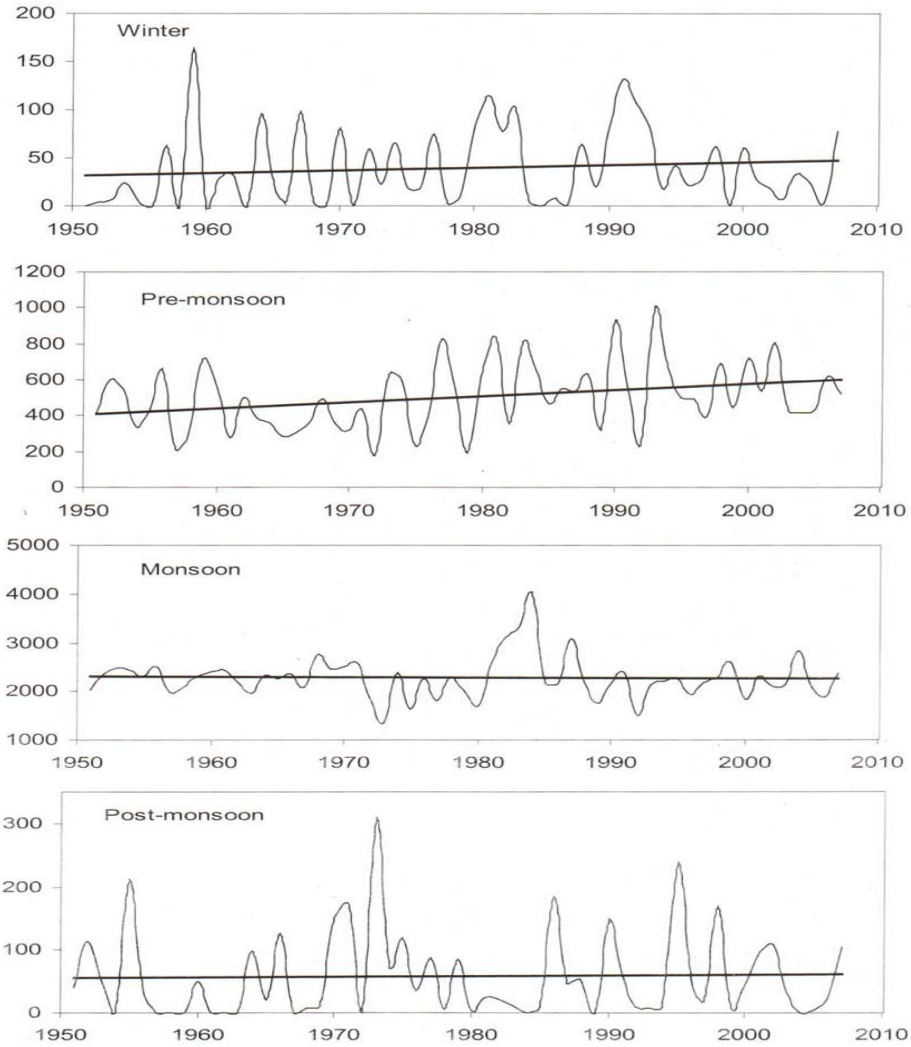


Fig. 4.14: Trend of mean temperature (°C) in Bangladesh during Winter season

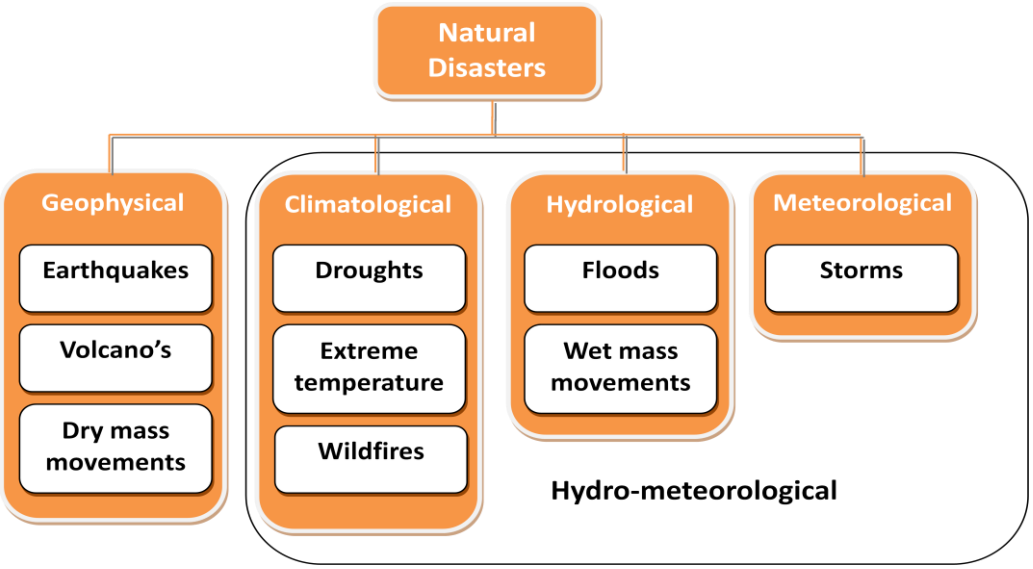
Year	Details
1791	Drought affected Jessore district, prices doubled or tripled.
1865	Drought preceded famine Dhaka.
1866	Severe drought in Bogra, district rice production hit hard and prices tripled.
1872	Drought in Sundarbans, crops suffered greatly from deficient rainfall.
1874	Extremely low rainfall affected Bogra, great crop failure.
1951	Severe drought in Northwest Bangladesh substantially reduced rice production.
1973	Drought responsible for the 1974 famine in northern Bangladesh, one of the most severe of the century ,
1975	Drought affected 47 percent of the country and more than half of the total population.
1978-79	One of the severest droughts in recent times, widespread damage to crops reduced rice production by about 2 million tonnes and directly affected about 42 percent of the cultivated land and 44 percent of the population.
1981	Severe drought adversely affected crop production.
1982	Drought caused a loss of rice production of about 53 000 tonnes while, in the same year, flood damaged about 36 000 tonnes.
1989	Drought dried up most of the rivers in NW Bangladesh with dust storms in several districts, such as Naogaon, Nawabganj, Nilpahamari and Thakurgaon.
1994-95 and 1995-96	Most persistent drought in recent times, caused immense damage to crops, especially rice and jute, the main crops of NW Bangladesh, and bamboo-clumps, a main cash crop in the region.

Rainfall



Increase of Natural Disasters

- Global warming is predicted to increase the frequency and intensity of tropical storms, floods, landslides, and wild fires.
- A serious disruption of the functioning of a community or a society causing widespread human, material, economic or environmental losses which exceed the ability of the affected community or society to cope using its own resources' (UNISDR, 2006).
- Floods, variable from year to year. Small increase of number of floods, decrease of number of affected people.
- Storms, variable from year to year.
- Decrease of tropical cyclone frequency.
- Positive relationship of frequency of 'Cyclone storm of hurricane intensity' and 'sea surface temperature' (IUCN, 2008).
- Likely that there is a relation between climate change and food, fresh water, and soil security.
- Possible that there is a relation between climate change and an increase of cyclone storms of hurricane intensity.



What Bangladesh is facing?

A meter rise of sea level would inundate

- a quarter of our landmass;
- displacing over 20 million people by 2050;

- Creating enormous humanitarian and political crisis beyond its national boundaries;
- Melting glaciers would further contribute to erratic weather pattern with prolonged monsoon floods and droughts leaving 40 million people without livelihood;
- With rising sea surface temperature, the intensity and the frequency of the storm would increase.
- Intrusion of saline water would further damage our agriculture sector.
- Such environmental impacts would have far-reaching effects on our dev. gains on economic growth, food security, health, water, ecosystems, and very existence as stable communities.
- Climate change conditions costing our national economy 1% of the GDP annually for over the last decade.
- Climate migrants from other parts of the country are already crowding our capitals for livelihood, placing extra burden on the existing infrastructure of the cities and causing social turmoil.

Recent Experiences includes –

- Cyclone –SIDR'2007
- Cyclone – AILA'2009
- Recurring Floods
- Desertification of North, North-west and South-west of Bangladesh
- Intrusion of saline water

Health, Nutritional & Agricultural Challenges

- Arsenic contamination poses major threat to health;
- Increased malnutrition among the poor contribute to the spread of communicable and non-communicable diseases;
- Increased incidence of different degenerative diseases due to salinity intrusion;
- Country is now largely food secure – but limits of rice cultivation has been reached in dry period with ground water irrigation;

Climate Change: Bangladesh Response

- The cornerstones of all actions, international or domestic, are to ensure security of food, water, energy and, livelihood (including health).
- To manage the impacts, Bangladesh has taken a two-pronged approach.

- It has been vigorously participating in the international negotiations process for realisation of the goals under the Bali Action Plan as well as preparing itself at home for necessary domestic action.
- Prepared National Adaptation Program of Action (NAPA) in 2005; identified 15 Priority projects.
- Prepared Initial National Communication and preparing Second National Communication.
- Made climate change an integral part of the new draft Poverty Reduction Strategy Paper (PRSP)
- Developed Bangladesh Climate Change Strategy and Action Plan (BCCSAP 2009)
- National Water Management Plan

Recent Success against Climate Change

- Bangladesh has already developed salinity tolerant, flood tolerant and shorter maturity varieties of rice. This will help in the short run.
- Extensive agricultural extension services are needed to make these varieties available to the farmers.
- But this is only the beginning: more varieties and appropriate ecosystem-based agricultural system need to be developed and popularized;

Bangladesh's Future Task on Climate Change

- An effective response to climate change challenges must strike a balance between mitigation and adaptation. Bangladesh urges all major emitters to collectively establish and implement a global target to stabilize the atmosphere over the short, medium and long term. The principle of common but differentiated responsibilities must be upheld.
- Adaptation is necessary to cope with the unavoidable dimensions of climate change and is essential in ameliorating near-term threats. Adequate physical, economic and institutional capacities can reduce the vulnerability of high-risk communities and groups. Comprehensive adaptation can help many communities to minimize economic losses induced by natural disasters.
- The post-Kyoto regime must generate new funds to facilitate development of technologies for a carbon neutral future in a scale that matches evolving requirements.