Climate Change: Impacts on Food, Agriculture and other Systems and their Adaptation

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Assessment Reports of IPCC

First Assessment Report (FAR) : 1990
Second Assessment Report (SAR) : 1996
Third Assessment Report (TAR) : 2001
Fourth Assessment Report (AR4) : 2007
Fifth Assessment Report (AR5) : 2014
Sixth Assessment Report (AR6) : 2018

Chap 7: Food Security and Food Production Systems

- New chapter introduced in AR5 for the first time. The relevant chapter in AR4 was 'Food, Fiber and Forest Products' (Chapter 5).

- Considers how far the climate and its change has affected current food production systems and food security and the extent to which they will do so in future.

- Two Coordinating Lead Authors, 6 Lead Authors and 2 Review Editors from 10 countries, and 10 Contributing Authors from 4 countries contributed to writing of Chapter 7 of WG II Report.

Main Findings of the Report

Observed Impacts - Agriculture & Food Production

- Impacts are evident on crops and terrestrial food production systems in several regions of the world. The evidence is strongest for natural systems.
- Negative impacts have been more common than positive ones.
- Positive trends are evident in some high-altitude regions.
- Impacts include (i) Shortening of the time to maturity of a crop with increasing temperature, (ii) decline in grain set when high temperatures occur during flowering, and (iii) increased water stress at high temperature throughout the growing cycle.
- Warming has benefitted crop production in some high altitude regions, such as northwest China, UK.

Observed Impacts (Contd.)

Impact of extreme temperatures: Large negative sensitivity to extreme daytime temperatures around 30^0C for several crops and regions has been documented indicating that temperature trends are important for determining past and future impacts of CC on crop yields.

Crop yield: Climate change has already reduced yield of food crops in tropics and subtropics. The crops affected include wheat, rice, maize, soybean, potato. IRRI (International Rice Research Institute) has reported a decrease of 10% in rice yield for every 1^0C increase in growing-season minimum temperature.

Agricultural land: A decline in good agricultural land in East Asia, due to secondary salinization and seawater intrusion, and increase in production of land in some areas in Central Asia has been observed.

Observed Impacts (Contd.)

Impacts of atmospheric CO_2: Stimulatory effect of CO_2 and damaging effect of elevated tropospheric ozone on crop yields have been confirmed. Interaction between CO_2, atmospheric ozone,, temperature and extremes.

Food Quality: nutritional quality of food and fodder including protein concentration and micronutrients are negatively affected by elevated CO_2 but these effects may be counteracted by effects of other aspects of CC.

All aspects of food security including access, utilization and price stability are potentially affected by CC.

Impacts on Crop/Food Quality

Temperature

High/Low**:** Causes pollen sterility in wheat

High/Low + elevated CO2: Reduces milling quality in rice

Daytime temp extremes + humidity**:** Affects rice sensitivity during flowering; occasionally lethal to crops

Night time temp extremes**:** Decrease rice eating quality as well as yield

Drought**:** May decrease/increase the mineral content of crops

Impacts on Crop/Food Quality (contd)

Elevated CO2:

- Decrease in protein concentration by 10-14% in wheat, rice, barley, potato, and 1.5% in soybean
- Decrease in mineral content (P, Ca, S, Mg,Fe, Zn, Mn and Cu) depending on crop species, soil type, plant tissue and water stress
- Increases crop and pathogen biomass, e.g. Crown root disease in wheat forming sterile ‘whiteheads’.
- Reduces yield and nutrient value of Cassava, staple food for 750 million people

Ozone:

Elevated O3 increases grain protein by reducing yield

Observed Impacts (Contd.)

Extreme Events

- Impacts are apparent immediately or soon after the event and are normally confused with slowly-occurring anthropogenic activity.
- **Floods**: The 2010 Pakistan super floods resulted in 2000 deaths, heavy loss to infrastructure and income loss of upto 50% in 88% households surveyed.
- **Frost** damage has constrained crop growth in most regions of the world.
- **Price Spikes:** Several periods of rapid cereal and food price increases have been observed following climate extremes in indicating sensitivity of markets to climate extremes. The 2010 Russian heat wave and their subsequent export ban more than doubled the global wheat prices by end of the year.

Observed Impacts (Contd.)

Livestock Sector

Like humans and plants, livestock have been impacted by CC, directly and indirectly;

Directly: chiefly through increased temperature, e.g. physiological stress on animal, stress on conception and reproduction, loss of productivity of milk, meat and egg, seasonal diseases and epidemics

Indirectly: through reduced quality and productivity of forage crops, increased water requirements for drinking, cooling of the animals and of the forage crops.

Observed Impacts (Contd.)

Water Resources

- Are at highest risk of depletion in Iran. With already little water, rainfall is expected to decline further in some areas. To meet crop water requirements, farmers are digging more and more wells, draining centuries old aquifers.
- In Iran, a cycle of extreme droughts since 1990 have caused many farmers to abandon the countryside and move to urban areas.
- Water shortage has given rise to conflicts.When Ethiopia started building a dam on Nile, Egypt who relies on its water threatened war. Iranian and Turkish dams along Tigris, Euphrates and other rivers raised similar protest. Building of controversial dams by India upstream on rivers flowing in Pakistan has resulted in litigation and threatened relations.

Observed Impacts (Contd.)

Aquatic Species:

- Climate trends are affecting abundance and distribution of harvested freshwater and marine species and aqua production systems in different parts of the world with negative impacts on nutrition and food security of vulnerable people in some tropical developing countries.
- Many terrestrial, freshwater and marine species have shifted their geographical ranges and some extinctions have occurred.

Adaptation – Principles for Effective Adaptation

- Adaptation is place- and context-specific; no single approach is appropriate for all settings. Implementation can be enhanced by providing information, policy, legal framework and financial support across levels (national to local, from individuals to government).
- Local governments and private sector are critical to adaptation of communities, households and civil society.
- The first step to manage future risks is reducing vulnerability and exposure to present climate variability. Integration of adaptation into planning and decision making can promote synergies with development and disaster risk reduction.

Adaptation – Principles (Contd.)

- Existing and emerging economic instruments such as public-private finance partnership, loans, payments for environmental services, insurance and risk pools can foster adaptation. Governments often play key roles as regulators, providers, or insurers.
- Poor planning or overemphasizing short term outcomes can result in maladaptation.
- Constraints, e.g. limited financial and human resources, different perceptions of risk, absence of adaptation leaders and limited monitoring, can impede adaptation planning and implementation.
- Co-benefits, synergies and trade-offs between mitigation and adaptation must be taken into account, e.g. (i) improved energy efficiency and cleaner energy sources leading to reduced emissions, (ii) reduced energy and water consumption in urban areas through greening cities and recycling water, and (iii) sustainable Agro-Forestry.

Adaptation and Managing Risks in Agriculture and other Food Systems

Food Systems: A range of potential options exists across all food systems activities, not just production, but benefits from potential innovations in food processing, packaging, transport, storage and trade are not sufficiently researched.

Crops: Agronomic adaptation improves yield by 15-18% of current yields but the effectiveness is highly variable ranging from potential dis-benefits to substantial benefits. Benefits are greater for crops in temperate rather than tropical regions.

Agricultural practices: Some practices can increase resilience of crops to temperature and rainfall variability, e.g (i) reducing erosion, soil organic C and N losses, (ii) Improving water holding capacity by adding crop residue and manure, (iii) adjusting animal stocking density to herbage and growth potential. .

Some Adaptation Strategies for Crops

a) Technological Improvement:

- Use of high-yielding, heat tolerant and drought-resistant crop varieties
- Improved fertilizer usage (split application, improved application method)
- Use of higher seed rate
- Alteration in sowing window

b) Improving water use efficiency:

- Using high-performance irrigation techniques, such as Sprinkler, Drip irrigation,etc.
- Deficit irrigation - irrigating crops at water-sensitive growth stages while avoiding irrigation or applying less water at water-insensitive stages.

c) Use of marginal lands for crops production

d) Plugging wasteful losses: from canal to field, and within the field

Adaptation and Managing Risks (Contd.)

Fisheries and Livestock : In fisheries, aquaculture and livestock production, adaptation will be strengthened by multi-level adaptive strategies to minimize negative impacts. For fisheries and aquaculture, these include policy and management to maintain ecosystem in a resilient state enabling occupational flexibility and development of early warning system for extreme events.

For livestock, strategies include adjustment to available resources, using breeds better adapted to prevailing climate, and removing barriers such as improving credit access.

Conclusions

- IPCC AR5 projects that climate change will continue under a range of socioeconomic scenario over the 21st century. If emissions continue to rise at the present levels, the global average temperature will be 2.6-4.8^{0}C higher than present.
- Climate change will cause decline in crop yields in some parts of the world. In Southeast Asia, as well as in the Middle East and Iran, decreases in yields will be in the range of 18-32% by 2080s. Climate change will also affect non-production elements such as processing, refrigeration, storing, transportation
- Increased hunger and malnutrition combined with population growth and increase per capita food demand pose challenge to meet this demand at a time when emissions are increasing.
- Adaptation is highly place- and context-specific and no single approach is appropriate across all regions, sectors and settings. Integrated crop/livestock systems will be a good option.

IPCC AR5 Chapter 07

Food security and food production systems

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Thanks