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Impacts of Climate Change on Agriculture

1. Introduction

The growing awareness of the impacts of climate change on agriculture is forcing policy makers to refocus on the sustainability of agricultural production. The paper focuses on therefore the impacts of climate change on the new models of agricultural development and what steps need to be taken to ensure the economic development of the agricultural sector. Climate change, which is widely accepted as the single most pressing issue facing society on a global basis, affects agricultural performance by altering the range and magnitude of climatic parameters which in turn affect biodiversity and terrestrial ecosystem services.

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2. Climate change - current trends

2.1 World Population

- 12,000 yrs ago : 10 million
- Start of Christian era to 18th century: 1 billion
- Next 100 years: 2 billions
- 1950 : 2.53 billions
- 2015:7.35 billions
- Expected by 2100: 11.21 billions

2.2 Carbon dioxide

- Global atmospheric concentration of carbon dioxide has increased from a pre-industrial value of about 280 ppm to 400 ppm in 2015. This exceeds by far the natural range over the last 650,000 years (180 to 300 ppm) as determined from ice cores.
- The annual carbon dioxide concentration growth-rate of 2 ppm per year during the past 10 years was larger than it has been since the beginning of continuous direct atmospheric measurements (1960 – 2005 average: 1.4 ppm per year).
- Annual fossil carbon dioxide emissions increased from an average of 6.4 GtC per year in the 1990s, to 7.2 GtC per year in 2000–2005.

2.3 Methane and Nitrous Oxide

- The global atmospheric concentration of methane has increased from a pre-industrial value of about 715 ppb to 1732 ppb in the early 1990s, and is 1845 ppb in 2015.
- The atmospheric concentration of methane in 2015 exceeds by far the natural range of the last 650,000 years (320 to 790 ppb) as determined from ice cores.
- The global atmospheric nitrous oxide concentration increased from a pre-industrial value of about 270 ppb to 328 ppb in 2015.

2.4 Oceans

- More than 90% of the energy accumulating in the climate system between 1971 and 2010 has accumulated in the ocean. It indicaters that oceans absorb more heat.
- Land temperatures remain at historic highs while ocean temperatures continue to climb

3. Climate change –Economy

3.1 Classic Theories of Economic Development:

Literature on economic development is dominated by the following four strands of thought:

- Linear stages of growth model: 1950s and 1960s
- Theories and patterns of structural change: 1970s
- International dependence revolution: 1970s
- Neo-classical, free-market counter revolution: 1980sand 1990s.

3.2 Rostow's Stages of Growth (1950s)

Rostow identified 5 stages of growth:

- The traditional society
- The pre-conditions for take-off
- The take-off
- The drive to maturity
- The age of high mass consumption

All advanced economies have passed the stage of take-off into self sustaining growth. Developing countries are still in the traditional society or the pre-conditions stage

3.3 Models of Dual Economy

- Structural transformation of the economy is taking place with the growth of the modern industry
- Output of the industrial sector depends on the quantities of capital and labour
- Output of the agricultural sector depends on the quantities of labour and land (which is assumed to be fixed)
- Labour is transferred from the agricultural sector to the industrial sector
- The process of self-sustaining growth and employment expansion continues in the modern sector until all of the surplus labor is absorbed

3.4 Climate Change Impacts on Economy

- Climate change is a large issue and every sector of the economy is affected.
- All aspects of our lives touched: environment, jobs, health, politics, national security, arts, religion, etc.
- Majority of the sciences and engineering disciplines are involved.
- Social sciences are interested.
- Business/Industry has a stake.
- Involves citizens, politicians, public policy experts, and advocates.

4. Climate change - Agriculture

4.1 Weather and climate extremes-impact on agriculture

- Of the total annual crop losses in world agriculture, many are due to direct weather and climatic effects such as droughts, flash floods, untimely rains, frost, hail, and severe storms .
- Between 2003 and 2013, natural hazards and disasters in the developing regions affected more than 1.9 billion people and resulted in nearly 500 million US dollars in estimated damage.
- The agriculture sector – including crops, livestock, fisheries and forestry – absorbs approximately 22 percent of the economic impact caused by medium- and large scale natural hazards and disasters in developing countries.
- Agricultural impacts from natural events and disasters most commonly include: alteration of ecosystems, contamination of water bodies, loss of harvest or livestock, increased susceptibility to disease, and destruction of irrigation systems and other agricultural infrastructure.
- These impacts can have long lasting effects on agricultural production including crops, forest growth, and arable lands, which require time to mature.
- Agriculture has been and will continue to be significantly affected by changes in climate conditions - quantity, quality, cost of production
- Existing adaption strategies can help offset many – but not all –effects over the next 20-30 years; effects are very likely to worsen significantly beyond then, especially if Green House Gas emissions remain high
- Improving the resilience of agricultural systems to climate change requires protection of the natural resource base (water & soil) and development of new strategies, tools, and practices for adaptation

4.2 Effects and Sensitivity Vary by Commodity

- Corn: High nighttime temperatures, high temperatures during pollination, water stress
- Soybeans: Water stress, high temperatures
- Wheat and small grains: Extreme events, water stress
- Rice: Temperature extremes during pollination, water management
- Cotton: High temperatures during boll fill
- Pasture and rangeland: water stress
- Fruit trees: High temperatures during fruit development
- Specialty crops: Water stress, high temperatures

4.3 Increased Biotic Stresses

- These will siginificantly affect agricultureInsect pests greater numbers, increased insecticide resistancegeographic ranges increases & decreases

- Imports from foreign sources Pathogen Host-pathogen response changes (plants, insects, non-crop reservoirs)
- Cultural control measures may be less reliable
- Extreme events can spreadWeeds Increased vigor, herbicide resistance
- Geographic range increases & decreases

4.4 Livestock Production

- Feed Grain & Forage
- Quantity & Quality Decrease
- Production Cost Increase
- Animal Heat & Humidity Stress
- Reduces growth, reproduction, production (meat, dairy, eggs)— Climate control costs increase
- Disease & Pests
- Frequency, intensity, distribution
- Abundance and/or distribution of competitors, predators, & parasites of vectors themselves.

5. Addressing climate change- Agriculture

5.1 Economic Development of Agricultural Sector

Economic development of agricultural sector refers to efforts that need to be made to increase farm production in order to enhance the farm incomes and meet the growing demand of increasing population.

This can be achieved in many ways such as increasing the cropped area, the number of crops grown, improving irrigation facilities, use of fertilizers and high yielding variety of seeds.

5.2 Effective Decision Making to Limit Climate Change Impacts and Ensure Economic Development of Agriculture

Effective decision making to limit climate change and ensure economic development of agriculture sector can be made by a wide range of analytical approaches for:

- Evaluating expected risks and benefits,
- Recognizing the importance of governance, ethical dimensions, equity, value judgments, economic assessments and
- Diverse perceptions and responses to risk and uncertainty .

5.3 Addressing Climate Change through Sustainable Agricultural Development Policies

Addressing climate change should be considered an integral element of sustainable agricultural development policies.

- Four of the 17 Sustainable Development Goals (SDGs) ie., 2, 6, 13, and 15 address the issue of weather, climate and sustainable agriculture.
- Sustainable Development Goal (SDG) No. 13 addresses the issue of combating climate change and its impacts.
- While addressing the other three SDGs 2, 6 and 15, it is important to implement climate change mitigation and adaptation strategies.

6. PARIS 2015 UN Climate Change Conference

COP 21 in Paris, Parties to the UNFCCC reached a landmark agreement to combat climate change and to accelerate and intensify the actions and investments needed for a sustainable low carbon future.

The Paris Agreement's central aim is to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius.

The Paris Agreement requires all Parties to put forward their best efforts through "nationally determined contributions" (NDCs) and to strengthen these efforts in the years ahead.

6.1 Progress made in the last one year on Paris Agreement

There are three broad and interlinked avenues of effort which will ensure the Paris goals are secured: national climate action by all countries across public and private sectors, international climate cooperation and a comprehensive shift in public and private investment to support both.

The recent UN climate change conference in Marrakech demonstrated that progress across all three avenues remains promising.

` So far 113 countries, including India, submitted their first NDCs.

6.2 India's NDC

Quotes the vision inspired by Mahatma Gandhi's famous exhortation; *"Earth has enough resources to meet people's needs, but will never have enough to satisfy people's greed"*.

India accounts for 2.4% of the world surface area, but supports around 17.5% of the world population. It houses the largest proportion of global poor (30%), around 24% of the global population without access to electricity (304 million).

About 30% of the global population relying on solid biomass for cooking and 92 million without access to safe drinking water.

India's NDC proposes a number of strategies to meet the Paris Agreement, while addressing the needs of India's people.

7. Key mitigation technologies in agriculture

- A large proportion of the mitigation potential of agriculture (excluding bioenergy) arises from soil carbon sequestration. Crop and grazing land management can be improved to increase soil carbon storage
- Restoration of cultivated peaty soils and degraded lands
- Improved rice cultivation techniques and livestock and manure management to reduce methane emissions
- Improved nitrogen fertilizer application techniques to reduce nitrous oxide emissions
- Dedicated energy crops to replace fossil fuel use
- Improved energy efficiency

7.1 Key Mitigation Technologies – Carbon Sinks in Forests

About 65% of the total mitigation potential is located in the tropics and about 50% of the total could be achieved by reducing emissions from deforestation

Forest-related mitigation options can be designed and implemented to be compatible with adaptation, and can have substantial co-benefits in terms of employment, income generation, biodiversity and watershed conservation, renewable energy supply and poverty alleviation.

The new online Learning tool on Nationally Appropriate Mitigation Actions (NAMAs) in the agriculture, forestry and other land use (AFOLU) sector of the Food and Agriculture Organization of the United Nations (FAO) supports the efforts of developing countries in the identification, development and implementation of country specific mitigation actions in the context of national sustainable development.

8. Climate Change Adaptation Strategies

There are several adaptation measures that the agricultural sector can undertake to cope with future climate change. These include:

- Changing planting dates
- Planting different varieties or crop species
- Development and promotion of alternative crops
- Developing new drought and heat-resistant varieties
- More use of intercropping
- Using sustainable fertilizer and tillage practices (improving soil drainage, no-till, etc)
- Improved crop residue and weed management
- More use of water harvesting techniques
- Better pest and disease control for crops
- Implementing new or improving existing irrigation systems (Reducing water leakage, soil moisture conservation - mulching)
- Improved livestock management (Providing housing and shade, change to heat-tolerant breeds, change in stocking rate, altered grazing and rotation of pasture)
- More use of agroforestry practices
- Improved forest fire management (altered stand layout; landscape planning; dead timber salvaging; clearing undergrowth; insect control through prescribed burning) Development of early-warning systems and protection measures for natural disasters (droughts, floods, tropical cyclones, etc)

9. Conclusions

- All the major international agreements, to which almost all countries are now committed, emphasize that countries should implement policies aimed at climate change mitigation and greater sustainability in the agricultural sector.
- Proper incorporation of weather and climate considerations in the development of improved strategies for this purpose requires a much longer time frame than has been used in the past.
- Priorities should be given for actions that maximize synergies between adaptation, mitigation, food production and sustainable development.
- Emphasis should be placed on a well coordinated research thrust on development pathways for effective natural resource management and sustainable agriculture.

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