IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

IMPACT OF CLIMATE CHANGE ON AGRICULTURE IN INDIA

Karthik Shankar, Jei Bhaasker B.S.M, Shashank Huli

Abstract

The production effects of climate change on Indian agriculture are investigated in this study article. To evaluate the impacts of temperature variations, rainfall variability, and extreme weather events on crop yields and output in various regions of the nation, the study uses both qualitative and quantitative methodologies. Data from secondary sources, such as academic journals, government papers, and statistics databases, are used in the paper. The results indicate that climate change is already having a substantial impact on India's agricultural production, with some regions seeing a decline in crop yields and others seeing an increase. In order to reduce the negative effects of climate change on agriculture and guarantee food security in the nation, the study also explores adaptation measures that farmers and policymakers might implement. The study concludes that climate change is a major threat to India's agricultural sector and that urgent action is needed to address this issue.

Key Words: Climate change, Indian agriculture, Temperature variations, Rainfall variability, Extreme weather events, Crop yields, Farmers

Introduction:

India is one of the largest agricultural economies in the world, with agriculture contributing to approximately 18% of its GDP and employing over 50% of the workforce. However, climate change poses a significant threat to the country's agricultural sector, which is already grappling with a range of challenges such as water scarcity, soil degradation, low productivity, and an increasing demand for food.

This study tries to offer a thorough examination of how climate change has affected Indian agriculture. The study will look at how crop productivity, land use, and water availability are impacted by climate change, as well as the steps that may be taken to lessen the consequences on Indian agriculture.

Section 1: Impact of Climate Change on Crop Productivity

Climate change is expected to have a significant impact on crop productivity in India. Changes in temperature, rainfall patterns, and extreme weather events such as floods and droughts can negatively affect the growth and yield of crops. For instance, a study conducted by the Indian Council of Agricultural Research (ICAR) found that a 2°C increase in temperature would result in a 4-5% reduction in wheat yields.

Similarly, changes in rainfall patterns can also have a significant impact on crop productivity. A study by the Indian Agricultural Research Institute (IARI) found that a 10% reduction in rainfall would result in a 7-8% reduction in rice yields. Furthermore, changes in rainfall patterns can also lead to waterlogging and flooding, which can damage crops and reduce productivity.

Section 2: Impact of Climate Change on Land-Use Patterns

Climate change is also expected to affect land-use patterns in India. Changes in temperature and rainfall patterns can lead to shifts in cropping patterns, as certain crops become less viable in certain areas. For instance, a study by the Indian Institute of Science (IISc) found that climate change could lead to a shift in wheat cultivation from the northern states to the eastern states of India.

Furthermore, changes in temperature and rainfall patterns can also lead to an increase in pests and diseases, which can affect the productivity of crops and lead to changes in land-use patterns. For instance, a study by the Indian Council of Agricultural Research (ICAR) found that climate change could lead to an increase in the incidence of pests and diseases such as brown plant hopper and blast disease in rice.

Section 3: Impact of Climate Change on Water Availability

Climate change is also expected to affect water availability in India, which is already grappling with water scarcity. Changes in rainfall patterns can lead to a decrease in the availability of surface water, which can affect irrigation and drinking water supplies. Furthermore, changes in temperature can also lead to an increase in evapotranspiration, which can further exacerbate water scarcity.

Additionally, climate change can also affect groundwater recharge, as changes in rainfall patterns can lead to a decrease in the amount of water that infiltrates into the ground. A study by the Indian Institute of Technology (IIT) found that climate change could lead to a 30-40% reduction in groundwater recharge in parts of India.

Section 4: Measures to Mitigate the Impact of Climate Change on Indian Agriculture

There are several measures that can be taken to mitigate the impact of climate change on Indian agriculture. These include:

1. Crop diversification: Encouraging farmers to diversify their crops can help mitigate the impact of climate change on crop productivity. By growing a variety of crops, farmers can reduce their reliance on a single crop and reduce the risk of crop failure due to changes in temperature and rainfall patterns.
2. Improving irrigation efficiency: Improving irrigation efficiency can help mitigate the impact of climate change on water availability.
3. Adoption of climate-resilient crops: Developing and promoting the adoption of climate-resilient crops can help mitigate the impact of climate change on crop productivity. These crops are specifically designed to withstand the effects of climate change, such as drought, heat, and pests, and can help ensure food security in the face of changing climatic conditions.
4. Soil conservation and management: Soil conservation and management practices such as conservation tillage, cover cropping, and integrated nutrient management can help improve soil health and increase its resilience to climate change. These practices can help reduce soil erosion, increase water infiltration, and improve nutrient availability, all of which can improve crop productivity.
5. Improving water management: Improving water management can help mitigate the impact of climate change on water availability. This can be achieved through the development of water storage infrastructure, such as dams and reservoirs, and the promotion of efficient water use practices, such as micro-irrigation and rainwater harvesting.
6. Enhancing agricultural research and extension services: Enhancing agricultural research and extension services can help promote the adoption of climate-resilient farming practices and improve the productivity and sustainability of agriculture. This can be achieved through the development of new technologies, the dissemination of information on climate-resilient farming practices, and the provision of training and support to farmers.

Research Methodology:

To study the impact of climate change on agriculture in India and its future consequences, a comprehensive review of existing literature and research studies was conducted. The review was conducted using a range of sources, including academic journals, reports from international organizations, government documents, and media articles. The review focused on identifying the key climate change impacts on Indian agriculture, the current and potential future consequences of these impacts, and the measures that can be taken to mitigate these impacts. The research methodology also involved an analysis of the current policy and institutional framework for climate change adaptation and mitigation in Indian agriculture.

Result:

Global Warming leads to lots of changes in our environment including Climate change, melting of glaciers, raising of sea levels, unseasonal rainfalls, hurricanes and floods, sea level depressions, etc. Increase in sea level leads to increases coastal erosion and elevates storm surge and loss of open lands. Change in climate impacts the agriculture and also the livestock. The impacts of global warming, such as changes in temperature, precipitation patterns, and extreme weather events, can have both positive and negative effects on agriculture production and livestock. For example, some regions may experience longer growing seasons and increased crop yields due to warmer temperatures, while others may face droughts, floods, or pests that can harm crops and livestock.

To address these challenges, there are both positive and negative directions that can be taken. Positive approaches include developing new technologies to improve crop yields, increasing agricultural resilience through better land management practices and crop diversification, and reducing greenhouse gas emissions to mitigate the effects of global warming. Negative approaches, on the other hand, could include using more pesticides and fertilizers, expanding monoculture farming, and relying on unsustainable practices that may further exacerbate environmental problems.

By assessing climate change, it is helpful to find new as well as overcome these risks. Govt of India is conducting a sustainable agriculture development program which is a crucial program to maintain a sustainable agriculture. Govt of India adopted few strategies. Adoption of appropriate mitigation technologies,

1. Cultivation of tolerant breeds of crops or varieties
2. Water and nutrient management practice can be adopted under climate facility and agriculture system.
3. Agro advisory.
4. Conservation agriculture proprietors to build the high soil organic carbon and to build continuous environment for plant growth through organic agriculture.

Cultivation of tolerant breeds of crops or varieties, to overcome the temperature stress and drought condition. So, basically it will impact the crops on productivity levels it will take rice and wheat because of increasing temperature. Rice and wheat are the c3 crops. C3 plants are a type of photosynthetic plants that use the C3 carbon fixation pathway to convert carbon dioxide into organic compounds. This is the most common pathway used by plants and occurs in the mesophyll cells of the leaves. In this pathway, carbon dioxide is combined with a five-carbon sugar called ribulose-1,5-bisphosphate (RuBP) to form two three-carbon molecules called 3-phosphoglycerate (3-PGA). C3 plants include most of the crops we eat, such as rice, wheat, soybeans, and cotton, as well as many trees, shrubs, and grasses. They are generally adapted to moderate temperature and moisture conditions, and their photosynthetic efficiency decreases at high temperatures and low CO2 concentrations. They are also susceptible to photorespiration, a process that occurs when Rubisco, the enzyme responsible for carbon fixation, reacts with oxygen instead of carbon dioxide, leading to a loss of energy and carbon. C3 crops will have a more impact than C4 crops. C4 crops are a group of plants that use a specialized carbon fixation pathway called C4 photosynthesis to convert atmospheric carbon dioxide into organic compounds. They are also called as Broadleaf crops. In C4 photosynthesis, carbon dioxide is first fixed into a four-carbon compound in the mesophyll cells of the leaves, before being transported to specialized cells called bundle sheath cells where it is converted back into a three-carbon compound and used in the Calvin cycle to produce organic compounds. C4 crops include many important food and feed crops such as maize (corn), sorghum, sugarcane, and millet, as well as several forage grasses. These crops are particularly well adapted to hot and dry regions, where they can maintain high rates of photosynthesis and growth even under water-limited conditions. They also tend to have higher yields and use water and nitrogen more efficiently than C3 crops. Indian institute of wheat and barley research, Karnel, Haryana says that based on probabilistic model change in climate decrease the yield of rice and wheat to an extent of 4-8% and even 10%. It was a US Collaborated program Based on Indo gangetic region. Before 2030 even a slight increase in temperature reduces the wheat production up to 27% in India. Therefore, in-order to overcome these conditions breeder has to develop tolerance variety which will adopt then continue to yield in forthcoming climatic scenarios.

The nutrient management should be improved for the efficient productivity and resource utilization. Plant cannot take sufficient amount of water at critical growth stages whenever it is required. Soil moisture is deteriorated and nutrients are not available at the right time for the plants to absorb. Nutrient intake plays a critical role in crop productivity. Adequate nutrient intake by plants leads to improved plant growth and yield, while inadequate nutrient intake can result in stunted growth, decreased yield, and susceptibility to disease. The availability and balance of nutrients in the soil are essential for the proper functioning of soil microbial communities, which are crucial for nutrient cycling and maintaining soil health, soil biodiversity which includes microbial diversity, is essential for nutrient cycling and the decomposition of organic matter. Microbes break down organic matter into nutrients that can be taken up by plants, and in turn, plants provide carbon to support microbial growth. The availability of nutrients, organic matter, and water in the soil affects the composition and activity of soil microbial communities. Therefore, maintaining soil biodiversity is crucial for sustainable crop production.

In urban areas, bulk soil is often compromised by construction, contamination, or other factors, which can affect soil biodiversity and nutrient availability. Strategies to enhance soil health in urban areas include the use of compost, mulch, cover crops, and soil amendments to increase organic matter and nutrient availability. Soil

testing can also help identify nutrient deficiencies and guide the application of fertilizers or soil amendments to improve soil fertility. Proper management of soil organic matter is critical for building healthy soils, enhancing soil biodiversity, and promoting sustainable crop production. The decomposition of organic matter provides nutrients to plants and improves soil structure, water-holding capacity, and aeration.

Therefore, it is important to manage crop residues and other organic materials to ensure that they undergo proper decomposition and contribute to soil organic matter. This can be achieved through the use of conservation tillage, cover crops, and other practices that promote the retention and recycling of organic matter in the soil. Bacterial and microbial load helps in decomposition of these residues in the soil. Fungi (cellulose degradable) also plays a very important role in decomposition to create a soil organic carbon. So, all these factors impacted drastically due to climate change. There is an impact in nutrient availability uptake by the crop. Eventually directly impact on the crop fields.

Agro advisory - now a days lot of start-ups come in order to monitor the crops in different growth stages during the cropping period. Soon after sowing, germination, vegetation growth, crucial stages like flowering, pollination, grain filling stages. At these stages if we monitor the crops through agro advisories like remote sensing agriculture. These are all the new methods yet to adopt by the Indian agriculture these methods are already available in the western agriculture.

The start-ups in India are initiating crop advisory program for better monitoring of the crops to overcome the impact of resilient agriculture what we call climate change agriculture wise to improve the productivity or to improve the sustainability. They monitor the soil temperature they monitor the soil moisture they also monitor the vegetation growth. There are different parameters like NDVI – Normalize difference in vegetation index, which measures the crop growth stages on certain parameters whether this crop is normal or abnormal.

NDVI is calculated by

$$NDVI = \frac{NIR-RED}{NIR+RED}$$

NIR stands for Near Infrared Reflected Light.

RED = Light Reflected in the red range spectrum.

NDVI (Normalized Difference Vegetation Index) is widely used in agricultural studies to monitor crop growth, identify crop stress, and estimate crop yields. NDVI is calculated by comparing the reflectance of near-infrared (NIR) and red light from vegetation. Healthy vegetation reflects more NIR light and absorbs more red light than stressed or non-vegetated surfaces. Therefore, higher NDVI values indicate the presence of healthy vegetation, while lower values indicate the presence of stressed or non-vegetated surfaces.

The outcome of an NDVI calculation for a specific pixel is always a value between minus one (-1) and plus one (+1). The plant will reflect more infrared wavelength and absorb more red wavelength if it is healthy. If a plant is unhealthy, it won't absorb as much red light and won't reflect as much infrared light. The result will be closer to +1 for healthier plants and closer to 0.5 for weaker plants. Crop monitoring, yield forecasting, irrigation control, and soil fertility mapping are further uses for NDVI.

Based on that we take steps on water management systems and nutrient management systems to bring its growth to normal. These are called crop advisories and lots of programs are initiated and lots of start-ups are working towards in this direction and even big companies are working in this direction. Companies like Mahindra & Mahindra and John Deere are manufacturing the tractors according to the crop advisory systems and remote sensing technology is another program where they will monitor the crops growth and create report and monitor crop under these conditions.

Conservation agriculture proprietors to build the high soil organic carbon and to build continuous environment for plant growth through organic agriculture. This is organic agriculture. Organic resources, organic approaches and organic products available are developed by companies. These things will help in building soil organic carbon. Therefore, when we increase the soil organic carbon definitely there will be an impact in overcoming these adverse environmental conditions.

There are some of strategies and technologies are available for the climate change adoption for a tolerant crop. Green gram (BM 2002 -1) and Sorghum (BD708) a crop that specifically developed in Maharashtra where rainfall is less than 645mm. Because Maharashtra is one of the drought zones in the country. These crops were grown in

Aurangabad and the Amaravati district respectively. The climate change in these regions has affected the growth of these crops drastically. These crops get affected seriously because of the drought and the rise in temperature. When it comes to Amaravati phase under fidelity Pigeon pea (AKT-8811) and sorghum (CSH-14) which introduced for drought stress condition in the Amaravati location where rainfall is 877mm and less than that. It also affects the lifestyle and poultry indirectly. When we try to cultivate these plants in these conditions it will definitely try to overcome these conditions and they have their own mechanism of adapting those situations- It is called as drought escape, drought avoidance and drought tolerance. How best plants can manage itself physiologically and altering its metabolic courses to overcome these test conditions. Under these courses it will think of reducing its lifecycle. When they are in drought avoidance they will try to adapt to the conditions and they will reduce its lifecycle. For example, Soya bean which is basically 105-110 days crop from C2 production at this condition it will reduce its lifecycle to 80-90 days. So, during this period it can't produce more. It cannot produce quality grains. Where soya bean is a highly protein rich and oil seed crop. So, it cannot efficiently allocate resources to the grain to produce a high-quality grain i.e., to make it more nutritious. Under these conditions such crop goes to live stock where soya bean is one of the important crops that 60-70% is used by the poultry industry. Under such conditions poultry field will be less nutritious and it will affect the productivity and livestock of the industry.

There are different programs which are conducted by government of India for agriculture. One of the eight Missions included in the National Action Plan on Climate Change (NAPCC) is the National Mission for Sustainable Agriculture (NMSA). This is one of the initiatives within the Indian government's system for coping with climate change. The management and conservation of water are given top attention by the Indian government. In order to accomplish this, with end-to-end solutions for source creation, distribution, management, field application, and extension activities, The Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) was created with the specific goals of enhancing water usage efficiency (More crop per drop) and extending irrigation coverage (Har Khet ko pani). The Cabinet Committee on Economic Matters, led by the Honorable. Prime Minister, gave the Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) its blessing.

The Per Drop More Crop initiative, which will be in effect throughout the country from 2015 to 2016, is being implemented by DA&FW. The Per Drop More Crop program primarily focuses on micro irrigation (drip and sprinkler irrigation systems) to increase water use efficiency at the farm level. From 2022 to 2023, PDMC will be implemented under RKVY.

The National Mission on Sustainable Agriculture's (NMSA) Centrally Sponsored Scheme (CSS), which was introduced in 2015, includes an expanded component of soil health management called the Paramparagat Krishi Vikas Yojana (PKVY)

1. The purpose of PKVY is to promote and aid organic farming, which will improve soil health. The program supports Participatory Guarantee System (PGS) For India (PGS- India).
2. An organic certification program that involves both farmers and customers and is both locally relevant and mutually trusted. PGS - India does not employ the "Third Party Certification3" framework. Each state and the federal government contribute 40% of the program's overall budget. Union Territories get all of the cash, whilst North Eastern and Himalayan States only receive 90:10 (Centre: State) of the overall budget. By 2017–18, the Scheme would establish 10,000 clusters of 20 ha each, with a goal of converting more than two lakh hectares of agricultural land to organic farming.

The objective is to produce agricultural items devoid of chemical and pesticide residues by employing low-cost, environmentally friendly approaches. The primary areas of focus for PKVY in promoting organic farming are as follows:

Promote organic farming among rural youth, farmers, consumers, and traders by utilizing the knowledge of experts from India's public agricultural research system. Disseminate the newest organic farming methods. Host at least one cluster demonstration in a village.

Greenhouse gas emission which is another important impact factor. Increase in greenhouse gases is like Carbon di oxide, Nitrous Oxide, Chlorofluoro carbon, Methane are the heteroatomic molecules that causes climate change. It adversely creates the climate change scenarios. Mainly It increase drought, temperature, floods, crop loss. There are lots of concepts, programs and approaches is also there to mitigate the greenhouse gases one is excess or imbalance utilization of fertilizers in the crops production system. Nitrous Oxide is one of the important factors in emitting the greenhouse gas. More use of nitrogen on plants leads to increase in Nitrous oxide. But usage of neem coated urea which slows down the dissolution of urea in the soil. It improves the efficiency of the

nitrogen hence it acts as a source of nitrogen to the plants. Which is also the supplier of nitrogen. It causes soil loss, leafing loss. What a better crop management system integrated nutrient management program. It also helps in mitigating the climate scenario and climate resilient program across the country. And the collaboration between the farmers and the research institutions, Funding agencies, non-Government organizations and private sectors combine to promote the climate change agricultural systems in the country.

Discussion:

The review of literature suggests that climate change is likely to have significant and negative impacts on Indian agriculture, particularly in terms of crop productivity, water availability, and land-use patterns. The impacts of climate change on agriculture are expected to vary across different regions and crops, with some regions and crops being more vulnerable than others.

The consequences of climate change on Indian agriculture are likely to be severe, with the potential for reduced crop yields, increased pest and disease pressures, and soil degradation. These impacts are likely to have significant implications for food security, rural livelihoods, and overall economic development in India.

However, the review also suggests that there are several measures that can be taken to mitigate the impact of climate change on Indian agriculture. These measures include crop diversification, adoption of climate-resilient crops, soil conservation and management, improving water management, and enhancing agricultural research and extension services.

The policy and institutional framework for climate change adaptation and mitigation in Indian agriculture is currently in its early stages, and there is a need for greater investment and support from the government and private sector to effectively implement and scale up these measures. Overall, the review suggests that urgent action is needed to mitigate the impact of climate change on Indian agriculture and ensure food security and sustainable rural development in the country.

Conclusion:

Climate change poses a significant threat to Indian agriculture, which is already grappling with a range of challenges such as water scarcity, soil degradation, low productivity, and an increasing demand for food. The impact of climate change on crop productivity, land-use patterns, and water availability is expected to be significant, and urgent measures need to be taken to mitigate its effects.

The measures outlined in this paper, such as crop diversification, adoption of climate-resilient crops, soil conservation and management, improving water management, and enhancing agricultural research and extension services, can help reduce the impact of climate change on Indian agriculture. However, a concerted effort is needed from all stakeholders, including the government, farmers, and the private sector, to ensure that these measures are effectively implemented and scaled up to achieve the desired impact.

Reference:

Jena, Jagadish & Misra, Sameer & Tripathi, Kailash. (2019). Normalized Difference Vegetation Index (NDVI) and its role in Agriculture.

National Mission on Sustainable Agriculture Report 2010: Link: https://agricoop.nic.in/Documents/Final_guidelines_1.pdf