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Changing Agriculture Patterns and Environment Concerns

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Abstract

Over fifty-percent of India's population depends on agriculture for their living, as it plays a major role in the country's food security. Agriculture has been and is still the foundation of the Indian economy. From Post-Independence subsistence-oriented and feudal systems to modern technologically sophisticated and market-driven agriculture, the sector's history is shaped by government reforms, technological advances, and socio-economic shifts. In this context this paper examines the Post-Independence agrarian structure, the transformative Green Revolution which comes with a number of environment concerns ranging from increased green-house gas emission contributing to global warming and climate change accompanied by land degradation, soil and water pollution. The paper also critically assesses the implications of climate change on crop production, water resources, and rural health and livelihoods and outlines future directions for sustaining agricultural growth and ensuring food security.

Keywords: Agriculture, Climate Change, Green Revolution, Greenhouse Gas, Soil Degradation

Introduction

Since Independence, India being an agriculture-based economy, has experienced remarkable transformations in its agricultural sector. Agriculture has been and continues to be the foundation of the Indian economy, supporting the livelihoods of more than half of the country's population and contributing significantly to national food security (World Bank, 2022) [21]. The sector's evolution from the subsistence-oriented and largely feudal systems of the early Post-Independence period to the technologically advanced, market-driven and self-sustained agriculture of modern times reflects a complex intersection of policy reforms, technological innovations, and socio-economic changes. In the years following Independence, the Indian government faced the immense task of addressing widespread poverty, food shortages, and rural underdevelopment. The agrarian structure at that time was characterized by significant disparities in land ownership, with a large portion of rural land concentrated in the hands of a few landlords, while millions of smallholder farmers and landless labourers struggled to live out a living (Prakash, 2021) [11]. The early years of post-Independence agriculture were also marked by an emphasis on achieving food self-sufficiency. India's First Five-Year Plan, launched in 1951, prioritized agricultural development by focusing on irrigation, fertilizer production, and the extension of modern agricultural practices. These initiatives laid the groundwork for future agricultural advancements. The immediate impact of agricultural advancement though was limited by infrastructural and institutional constraints (Dantwala, 1986) [4]. The country continued to struggle with food insecurity, aggravated by population growth and frequent droughts. The green revolution, which began in the mid-1960s, marked a significant turning point in Indian agriculture. Faced with the threat of widespread famine and a growing food deficit, the Indian government, with support from international organizations, embarked on an ambitious program to modernize agriculture to increase production to meet the need of increasing large population. The introduction of High-Yielding Variety (henceforth HYV) seeds, chemical fertilizers, and pesticides coupled with investments in irrigation infrastructure, led to a dramatic increase in food grain production, particularly in Wheat and Rice (Evenson and Gollin, 2003) [5]. The Indian states like Punjab, Haryana, West Bengal and Uttar Pradesh became the major contributor of this agricultural transformation, especially in case of rice production, helping India achieve self-sufficiency in food grains and reducing its dependence on food imports.

While the green revolution is widely credited with preventing famine and fuelling economic growth, it also brought about significant environmental and social challenges. The intensive use of chemical inputs not only led to soil degradation, water

pollution but also the depletion of groundwater resources, particularly in regions that were heavily relied on irrigation. Additionally, the focus on only few varieties of rice and other food grain range of crops reduced agricultural biodiversity and increased the vulnerability of farming systems to pests, diseases, and climate change (Shiva, 2016) [17]. In case of loss in agriculture biodiversity from approximately 3000 varieties to only few varieties of crops also lead to loss in nutritional values carried by them since generations along with their respective vulnerability to pests and diseases. The benefits of the Green Revolution were also unevenly distributed, leading to regional disparities and exacerbating socio-economic inequalities as the northern States of the country was majorly leading the Green Revolution. The period following the green revolution saw a gradual shift towards diversification in Indian agriculture recognizing the risks associated with over-reliance on a few staple crops and further risk associated with them, policymakers in the government and farmers began to explore alternative agricultural practices for additional income, increased social and financial security. Hence, the 1980s and 1990s witnessed a growing focus on horticulture, dairy farming, poultry and fisheries, driven by the need to increase rural incomes of the farmers and improve food security (Ramasamy, 2004) [13]. This period also saw the rise of integrated farming systems, which combined crop production with livestock production and other allied activities for better use of resource and to reduce the risks of the changing environment.

The economic liberalization of the 1990s brought further changes to Indian agriculture which increased global competition along with raising environment concerns further. The liberalization policies opened up the agricultural sector to global markets, encouraging private sector participation and foreign investment. This shift resulted in increased agricultural exports, the introduction of new technologies, and greater access to credit and investment (Chand, 2004) [3]. However, it exposed Indian farmers to global market volatility and competition, demanding the creation of improved infrastructure, such as storage facilities and transportation networks, to serve the demand of country's expanding agricultural sector combined with an increased use of other hazardous agricultural inputs like pesticides, fertilizers etc. more aggressively to increase production of food grains, all of which had major consequences for the environment.

Changing pattern of Agriculture and Climate change

While the green revolution is widely regarded as avoiding hunger and boosting economic prosperity, it also created huge environmental and social difficulties. The heavy use of chemical inputs resulted in soil deterioration, water contamination, and groundwater depletion, particularly in irrigation-dependent regions. Furthermore, focussing on only a few types of rice and other food grain crops reduced agricultural biodiversity and increased the vulnerability of farming systems to pests, diseases, and climate change (Shiva, 2016) [17]. The advantages of the green revolution were also unevenly distributed, contributing to geographical inequities and deteriorating socio-economic equality. It is in place to mention that climate change is one of the most significant concerns affecting Indian agriculture in recent years. The Indian monsoon, which is essential to the country's production of crops, is becoming increasingly variable and erratic because of climate change, resulting in unpredictable rainfall patterns and delay in start of rainfall season, extended droughts, and major flash floods. These changes have significant implications for crop yields, water availability, and rural livelihoods, particularly for smallholder farmers who have limited resources to adapt to these challenges (Aggarwal and Singh, 2010) [1]. Rising temperatures and an increasing number of extreme weather events are also harming the viability of traditional farming systems, making it more difficult to maintain sustainable level of production in agriculture.

The green revolution, which began in the mid-1960s, marked a significant turning point in Indian agriculture. The introduction of HYV seeds, chemical fertilizers, and pesticides with proper irrigation led to a dramatic increase in food grain production, particularly in staple crops like wheat and rice. The states of Punjab, Haryana, and Uttar Pradesh were the flagbearer of this transformation, contributing to India's self-sufficiency in food grains (Pingali, 2012) [10]. However, the environmental costs of the green revolution were significant. The widespread use of chemical inputs led to soil degradation, water depletion, and increased vulnerability to pests and diseases (Jat *et al*., 2020) [7]. Additionally, the focus on monoculture reduced agricultural biodiversity and made farming systems more susceptible to the impacts of climate change. The green revolution also led to significant regional disparities, with the benefits largely concentrated in a few states while many other regions were left behind (Gulati and Kelley, 1999) [6]. This disparity has had lasting socio-economic impacts, contributing to rural poverty and migration (Singh *et al*., 2018) [18]. Moreover, the environmental degradation caused by intensive farming practices has raised concerns about the long-term sustainability of the green revolution model.

Although the green revolution did increase the productivity of food grains but several studies also show that it had a negative impact due to number of concerning reasons. One of such is greenhouse gas emission responsible for global warming and climate change. A study by Proceedings of National Academy of Sciences (PNAS) in 2013 estimated that global greenhouse gas emission has been 5.2 to 7.4 gigatons higher between 1965 to 2004 due to green revolution worldwide. Sah and Devakumar (2018) evaluated the greenhouse gas emissions from Indian agriculture over the previous 50 years between 1960 to 2010, the amount of emissions increased by 161%, from 14.81 TgCE/year (0.12 tCE ha−1yr−1) in 1960 to 38.71 TgCE/year (0.28 tCE ha−1yr−1) in 2010. It was discovered that the primary sources of greenhouse gas emissions in Indian agriculture were livestock and rice production (Vetter *et al*., 2017) [20]. It comes primarily from transition from traditional animal and human energy sources to carbon-intensive diesel and electricity-dependent machinery used for production as well for the transportation of agricultural crops. This also leads to an increase in the usage of agricultural inputs, mainly chemical nitrogen fertiliser and pesticides. The overuse of chemical inputs has led to soil degradation, reduced soil fertility and contamination of water bodies as well.

The Global Land Assessment of Degradation (GLASOD) in 1991 found that 43% of agricultural land of south Asia is degraded to some extent. Similarly, for India, Sehgal and Abrol (1994) [16] estimated that 64% of the land area is degraded to some extent, with 54% moderately to severely degraded. This shows that the green revolution in India as

well as other reforms in agriculture in the world is causing a lot of damage to the agricultural land, water resources and other ecology connected to the agricultural production. In case of irrigation, the intensive irrigation practices have resulted in the depletion of groundwater resources, particularly in regions like Punjab and Haryana. The emphasis on monoculture (growing one crop species in the field at a time) has also reduced agricultural biodiversity, making the system more vulnerable to pests, diseases, and climate change. Green revolution also impacted the health of individuals connected to the agricultural practices because use of pesticides increases the likelihood of cancer in some rural villages due to many reasons like over-usage of chemicals, non-compliance to usage of masks etc. In 1989, WHO and UNEP estimated that there were around 1 million human pesticide poisonings annually. Some 20,000 (mostly in developing countries) ended in death, as a result of poor labelling, loose safety standards etc which shows the negative impact of green revolution on health of agricultural society.

Climate Change Impacts

Climate change has emerged as a major challenge to Indian agriculture, affecting crop yields, water resources, and rural livelihoods. The Indian monsoon, which accounts for about 70% of the annual rainfall, is critical to Indian agriculture, and changes in its timing, distribution, and intensity due to climate change have already begun to impact crop production along with yields and water availability (Asha *et al*., 2012) [19]. Temperature fluctuations, erratic rainfall patterns, and the increased frequency of extreme weather events pose severe threats to crop production and food security (Singh *et al*., 2018) [18]. These events have become more and more common with the changing climatic condition which impacts not only the individuals but also the agriculture production. Studies have shown that rising temperatures could lead to significant yield reductions for major crops such as wheat, rice, and maize (Aggarwal and Singh, 2010) [1] which are the staple crops for major population of the country. For instance, higher temperatures during the flowering and grain-filling stages of wheat can lead to reduced yields, while erratic rainfall can cause water stress during critical growth periods of rice (Asha *et al*., 2012) [19]. The vulnerability of smallholder farmers, who constitute the majority of Indian farmers intensify the impact of climate change as they have limited resources to adapt to changing conditions (Mall *et al*., 2006; Kotwal *et al*., 2011) [9, 8]. Farmers having small portions of land have very low adaptive capacity and knowledge to combat the effect of climate change that further creates hardships for their livelihood. The impacts of climate change on Indian agriculture are becoming increasingly evident with significant implications for food security and rural livelihoods. Rising temperatures, changes in precipitation patterns, and the increased frequency of extreme weather events are affecting crop yields, water availability, and soil health (Mall *et al*., 2006; Asha *et al*., 2012) [9, 19]. The Indian monsoon, which is critical for agriculture, is becoming more unpredictable, leading to both droughts and floods that can have devastating effects on the crops.

To mitigate the impact of climate change on agriculture, India has been exploring various adaptation strategies. These include the development and adoption of climate-resilient crop varieties, improved water management practices, and the promotion of sustainable farming techniques (Yadav *et al*., 2018) [22]. Climate resilient varieties are necessary as they can withstand the higher temperature, sudden rainfall and higher velocity of wind. These are the varieties which can grow quickly in case of late monsoon arrival with less irrigation. The use of technology, such as precision agriculture, which involves the application of technology to optimize inputs and monitor crop conditions is also gaining attention as a means to optimize resource use and enhance productivity under changing climatic conditions. Along with this agriculture sector also needs support by the government to promote agriculture sector. Government initiatives like the National Mission for Sustainable Agriculture (NMSA), part of the National Action Plan on Climate Change (NAPCC), are focused on promoting sustainable agricultural practices and enhancing the resilience of farming systems. Also, farmers should be given the loan easily and on affordable rates for agricultural inputs as to procure seeds, pesticides and fertilizers so, it can increase their adaptability for agriculture.

So, adaptation strategies are crucial for mitigating the impact of climate change on agriculture. Careful management of resources like soil, water, and biodiversity is needed to mitigate the effects of climate change on agriculture (CCSP, 2008) [12]. Furthermore, the development of drought-resistant and heat-tolerant crop varieties through biotechnology offers promising solutions to the challenges posed by climate change. The Indian government should support farmers by offering value-added weather services in order to mitigate the effects of climate change on agriculture and food production. All those policies which are being run by the government either for promoting organic farming, use of technologies for better use of agriculture input like irrigation, fertilizers or pesticides etc, or different incentives given for different purpose should be popularize among the farmers so that the benefits reach the larger extent. These efforts are crucial for ensuring the long-term sustainability of Indian agriculture and safeguarding the livelihoods of millions of Indian farmers.

Conclusion

The evolution of Indian agriculture since 1950 reflects a journey of significant transformations, driven by policy reforms, technological advancements, and continuous efforts to address emerging environmental challenges. The green revolution brought about remarkable increases in food grain production but also raised concerns about environmental sustainability. This green revolution, which came with rapid increase in food grains production enables self-sufficiency to the country but also puts a lot of environment concerns ranging from increased greenhouse gas emission, groundwater degradation with pollution and soil degradation causing lot of damage to agricultural and environment biodiversity. The period following the green revolution saw a gradual shift towards diversification in Indian Agriculture recognizing the risks associated with over-reliance on a few staple crops and further risk associated with them, policymakers in the government and farmers began to explore alternative agricultural practices for additional income, increased social and financial security. As a result, in the 1980s and 1990s, there was a greater emphasis on horticulture, dairy farming, poultry, and fisheries, motivated by the desire to boost rural farmers' incomes and improve

food security. This period also saw the rise of integrated farming systems, which combined crop production with livestock production and other allied activities for better use of resource and to reduce the risks of the changing environment. Lately, the shift towards diversification and economic liberalization opened up new opportunities for growth but also highlighted the need for better infrastructure and market access and better practices for sustainable agriculture. In recent years, climate change has emerged as a critical challenge, threatening the productivity and sustainability of Indian agriculture. Addressing these challenges will require a multi-pronged approach, involving government intervention, private sector participation, and the active involvement of research institutions and civil society. By focusing on innovative technologies, sustainable practices, and comprehensive policy support, India can ensure the long-term sustainability of its agricultural sector, improve the livelihoods of millions of farmers, and maintain food security in the face of climate change.

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