



Sustainable Agriculture and Food System in India: Challenges and Opportunities

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ABSTRACT

The fast-paced change has been occurring in India as it strongly prepares to gain its trademark of the first developed nation as the second could be overtaken earlier than expected. However, such a scenario has created some apprehension over the bridging population; prompting the experts to coin the phrase-"sustainable development"-so that the achievements of an ever-produced land can remain accessible to generations that come after them, a subject dominating the limelight in recent years. While other fields continue to flourish, agriculture in India has always been considered the backbone of the economy. Hence, the focus has shifted heavily in recent times toward creating a strong backdrop for agriculture and thus seriously emphasizing sustainable agriculture. Recently, India has been witnessing rapid transformation toward development and maybe surpassing its other counters in this regard sooner than one could imagine. However, its development has also brought with it concerns of population growth, a matter which presently is warranted by experts advocating for "sustainable development" to ensure the country's attainment remains within reach for future generations. The agricultural basis for India continues to have a running blood through it, so in order to protect agriculture, now much stress has been placed on sustainable agriculture.

Keywords: Sustainable Agriculture, Food Security, Environment, Poverty, Population.

INTRODUCTION

Agriculture is one of the country's highest private sectors, greatly influencing the figures for GDP and employment. It also forms the basis for sustainable economic development by balancing the use of resources in nature. Farming serves as the mainstay of the economy in rural areas, where nearly two-thirds of the Indian population depends on it. Hence, the performance of this sector is consequently tied up closely with the entire economic structure, employment, and the incidence of poverty. With urbanization and industrial growth setting in and land resources becoming scarce, India has to allow agriculture to raise its productivity as a measure of economic growth. Growth in the agricultural sector has been proven to increase the income of the country's poorest by two to four times as much as growth in other sectors. The steady performance of the agricultural sector holds importance for India as food security is a concern for the nation's 1.3 billion and increasing population. According to the Agricultural Census of India, in 2019, 93.094 million agricultural households were there in rural India which was about 54.0 percent of all agricultural households. Further, agriculture contributes to about 15.4% of the total GDP of India [1], in relation to fewer rural households that need food for a growing population.

Concepts that relate to food security concepts have changed their emphasis over several decades. By the 1970s, the major concern was with food supply and food production, while methods of distribution were also being improved. It was also observed that increasing the purchasing power of the vulnerable groups helped in arresting their food insecurity. We feel at this stage of development that India should broaden its scope to include nutritional security for the population beyond just food security in terms of calorie security to the poor and total food grain security. With this understanding, the present study seems to be justified in suggesting a much broader concept of food security. The capacity of the nation has been able to avert famines for the last fifty years, but before the mid-1960s, chronic food grain shortages formed the economic norm in India. This chronic deficiency in the supply of food in the rapidly rising demand had compelled the government to depend on large-scale imports and food controls on numerous occasions. These events were followed by the implementation of a policy, known as the Green Revolution, to increase food grain production within the country. India was thus able to achieve a reasonable degree of self-sufficiency in food grain production by the first half of the 1980s. It, however, only achieved this on a macro level and not on a more practical level of food security.

SIGNIFICANCE OF STUDY

This article mainly focused on agricultural practices in India with respect to food grains and food security systems, and how to manage them sustainably in view of the present-day situation. Since a large chunk of the Indian population, some 42.83 percent [2], is either directly or indirectly engaged in agriculture, which ironically eats up a very large land area in the country, this very issue is of paramount importance for India. The need for studying sustainable agriculture and food systems in India can be enumerated as follows:

1. With such a massive population in India and having climate change as an additional factor stressing the urgency, there comes an imperative need to seek every opportunity to guarantee that food security has been achieved by promoting sustainable agriculture.
2. Food Security Challenges: Given the demographic magnitude of the country and climate alterations, it has become a prerequisite to scrutinize all possible innovative alternatives for ensuring food security, with the bulk falling on sustainable agriculture.
3. Enhancing Rural Livelihoods: Sustainable agriculture has the power to increase income generation and improve the well-being of people staying in rural areas, which is so important for the economy and, therefore, for the overall development of the nation.
4. Policies and Practices: Perhaps the most policy-relevant use of the research could be in shaping regulations, programs, and practices in sustainable agriculture for India to meet its goals of sustainability.
5. Informing Policies and Practices: Findings obtained from this study will influence the forging of policies, design of programs, and practices related to sustainable agriculture to help India in achieving the sustainability goals.

INDIAN AGRICULTURE:AN OVERVIEW

Agriculture serves the Indian economy to be the most important sector. It provides sustenance to nearly two-thirds of the labour force residing in the rural parts of the country. Thus, it provides employment to 65% of the labour force, contributes roughly 27% towards the GDP, accounts for about 21% of total exports, and supplies raw materials to various industries. [These] Also, the contributing worth of the livestock sector to the nation's GDP is approximately 8.4%, while it contributes 35.85% of the agricultural production. [3]

Roughly 75 percent of the population resides in urban areas and practices agriculture, whereas some 43 percent of the land is designated for agricultural activities. Further, food production there runs roughly to 211.17 million metric tons. [4]

ACHIEVEMENTS IN INDIAN AGRICULTURE

India has its population largely dependent upon agriculture, with some 75% living in urban regions, while approximately 43% of land is considered suitable for agricultural undertakings. Furthermore, it is active to generate around 211.17 million tons of food production. [4]

1. The Green Revolution (1968) initiated the Intensive Agriculture District Program (IADP) as part of its strategies prior to launching the Green Revolution. NABARD was established nationwide as the National Bank for Agriculture Development. The focus of agricultural priorities shifted towards high-yielding varieties of plants and modern inputs, which included chemicals and pesticides, facilitating mechanization to boost agricultural output while making slight adjustments in the amount of land cultivated.
2. Professor M.S. Swaminathan characterizes himself as supportive of women, nature, and the economically disadvantaged during the Ever-Green Revolution that commenced in 1996. Enhancements in education, technological progress, biodiversity preservation, improved soil quality, and increased climate resilience in food crops define the components of this ever-green revolution. The main goal of this transformation is to achieve maximum output with minimal land cultivation, along with restricted use of water and fertilizers. During his visit to New Delhi in March 2010, the US President announced cooperation in the Indian agricultural sector aimed at establishing an evergreen revolution that would contribute to global food security.
3. Following the triumph of the Green Revolution, people gained confidence in farming, leading to the era of the Technology Mission. This strategy focused on three foundational principles: conservation, consumption, and commerce. The comprehensive approach to managing the production-consumption chain resulted in gradual yet meaningful successes, such as in milk and egg production.
4. The increase in fish production through the Blue Revolution (Water, Fish) is partially influenced by the rise in demand for seafood due to healthier eating habits. The availability of wild fish is declining rapidly. This revolution offers significant employment prospects to landless labourers and women, granting them a sense of empowerment.
5. India is strategically positioned to become a prominent player in the Global Bio-tech Arena. Agriculture biotech in India holds vast potential for growth, allowing the country to lead in the production of transgenic crops and various genetically engineered vegetables by 2010. The agri-biotech sector in India has been expanding at an astonishing rate of 30% over the past five years. The food processing industry, viewed as a key driver of the Indian economy, is currently experiencing a growth rate of 13.5%.^[5]

FOOD POLICY IN INDIA SINCE INDEPENDENCE

Since gaining independence, India has not witnessed famine. However, vast population growth following independence has sunken millions into chilling destitution. Thus, the Indian government has had to institute extensive food policy measures. These policy measures comprise of steps taken, from time to time, to enhance food grains production within the country and to maintain reasonable price stability. Two most important objectives of food policies in India are: firstly, to protect the producers' interests, and secondly, to safeguard the interests of consumers. This balancing of interests on either side of the spectrum is depicted in the stated objectives of the national food policy of India, which are as follows: -

1. The government must create incentives that promote self-sufficiency in food grain production, ensuring that producers receive adequate motivational benefits.
2. To protect consumers' welfare, special intervention measures are necessary, with organizations ensuring support for vulnerable population groups through effective cost-control initiatives.
3. It is crucial to maintain sufficient reserves of food grains to counteract the impacts of annual production fluctuations. The Food Corporation of India (FCI), a state agency, is responsible for managing these reserve stocks.
4. Efforts must be made to promote regional fairness in the distribution of food grains.

5. The government's actions in this regard include the transportation of food through the Public Distribution System (PDS), the expansion of fair price shops across the nation, and the introduction of income-generating programs aimed at improving lower-income groups' access to food resources.

OBSTACLES AND POSSIBILITIES IN SUSTAINABLE AGRICULTURE AND FOOD SYSTEMS

Since independence, India has been spared from famine. Yet over the past few decades, some fast population growth has created a pressing and intemperate food crisis affecting millions of people in the country. For a reaction to the situation, hunger policy in India now flanks a greater profile. The food policy consists of measures taken at different times to channel food grain production and supply into reasonable price stability in the domestic market. Basically, the food policies in India are centered around two broad objectives: first, safeguarding the producers, and second, protecting the interest of consumers. This dichotomy is very much clear in the objectives of India's national food policy, under which we have:-

In terms of key challenges faced by Indian agriculture, 85% of land is categorized as marginal and small farms usually less than 2 hectares [9]. Financing is scarce, limited technology and mechanization are in use, and infrastructure is absent, leading to an inefficient employment of the weather and marketing and distribution channels inappropriate for high-value crops. Solving these challenges calls for innovative technological solutions based on sound scientific principles, community participation, and sturdy infrastructure and supportive policies.

CHALLENGES IN THE AGRICULTURE SECTOR

The world is much diverse, for agricultural methods vary. This very diversity gives rise to so many sustainable farming methods in the world, of which there can be many more in different parts of the same country. So, agriculture in India has a bundle of international and local problems; some of these are given below:-

1. A fundamental review of the current agricultural system is necessary to address adverse climatic, social, and economic conditions.
2. It is essential to optimize water utilization in irrigation systems while ensuring the health and fertility of the soil and the availability of nutrients.
3. Reducing losses caused by pests, diseases, and weed competition is crucial.
4. Agriculture must decrease its reliance on non-renewable resources derived from fossil fuels.
5. Maintaining a diverse range of crop germ-plasm is important for facilitating crop breeding in response to a changing climate, thereby enhancing production resilience.
5. Implementing biological science-based technologies and approaches can help increase food grain production sustainably.
6. Enhancements in crop management and agricultural practices are needed.
7. Various strategies must be adopted based on different regions and situations.
8. There is a necessity to balance investment in innovative new methods that can significantly impact productivity with financing for strategies that deliver more modest improvements in a shorter timeframe.
9. One of the most significant challenges for sustainable agriculture remains the issue of climate change.

ROLE OF AGRICULTURE IN ACHIEVING SUSTAINABLE GOALS

Agricultural methodologies are, as we all know, dissimilar in different territories, implying each country has some methods of its own for sustainable agriculture which may differ even in various regions of the very same country. Thus, Indian agriculture faces several problems both at the international as well as local level, some of which are given below:-

In tandem with hunger and malnutrition, there is a parallel cut of poverty on the layers of Water and Energy-WFI-laterally relating to climate change and economy. On a broad scale, agriculture paves the way for a better living environment in the underdeveloped rural areas so that there can be nutritional security. The highest among all Sustainable Development Goals (besides SDG 2, eliminate hunger, and ensure food and nutrition security) is perhaps the most challenging but within reach through sustainable agricultural practices.

According to Dobermann, sustainable agriculture requires at least six principal factors:-

1. Farmers in all developing countries should be able to earn a living and sustain themselves throughout the entire value chain.
2. It is necessary that the entire population can achieve food security by ensuring access to nutritious food.
3. The method must be adaptable to the impacts of climate change.
4. It should also have the capacity to counteract greenhouse gas emissions.
5. The strategy needs to minimize environmental harm, including the loss of biodiversity, pollution of water, soil erosion, destruction of habitats, and contamination from pesticides and herbicides.
6. The practices should align with local cultural traditions and the practices of indigenous industries.

The analysis of surface temperatures all over this country shows a steady increase with time, a warming tendency concurrent with that of the global average temperature. These increases in global temperature seriously affect the hydrologic cycle by increasing the rate of evaporation of surface water and that of transpiration from vegetation. Consequently, changes in one of these aspects can exert influences on others: precipitation-intensity and timing; fluxes of water from precipitation into surface and under surface environments (lakes, soil moisture, groundwater); and finally, the degradation of agricultural lands for food shortages. The Fourth IPCC Assessment Report states that by the middle of the 20th century, global warming was over 90 percent likely to have resulted from human-made greenhouse gases (GHGs). Subsequently, if no policy interventions occur, the average global temperatures by 2090 to 2100 would be set to rise between 1.1°C and 2.9°C under the IPCC lowest emissions scenario, and between 2.4°C and 6.4°C under the highest emissions scenario, over 1980-1999." [10]

The first half of the 20th century saw two drought-free periods, between 1921 and 1930 and between 1931 and 1940. On the contrary, the 21st century has already had three drought-free decades within its first ten years. When factoring in the distinction between the decade 2010 to 2020 and the decade 2020 to 2030, three years in the latter have passed without drought. So, droughts did not occur in the country till now. Looking aside 2020 to 2030 for the time being, between 1991 and 1995 was also another drought-free period. The droughts of 1965-66, 1987, 1999-2000, 2002-2003, and 2013-14 were well-managed and did not exacerbate India's food insecurity, mainly due to the existence of buffer food stocks in India[11]. But food production is still greatly dependent on rainfall and its distribution in India. The rains are provided by the south-west summer monsoon and contribute 78% of annual rainfall, thus irrigating crops all over India. This becomes very important in context to the fact that the production of rain-fed crops suffers immensely during the years of very low rainfall. Let me also reiterate here that the 2014 drought affected just that area, which has been dried up by the previous four major droughts.

OPPORTUNITIES TO SUSTAINABLE AGRICULTURE AND FOOD SECURITY

Eco-friendly farming methods and reliability in food supply are the elements of environmental well-being, economic resilience, and social justice. A few major opportunities that will help India in the attainment of these objectives are:-

1. **Policy Reform:** Many issues can be addressed by modifying agricultural policies to focus on adaptability and sustainability. It is crucial to implement policies that support smallholder farmers, encourage the adoption of sustainable practices, and optimize water use. Strengthening the enforcement of existing policies and promoting cooperation among stakeholders can enhance their effectiveness.
2. **Sustainable Farming Practices:** Implementing sustainable methods such as agro forestry, integrated pest management, and organic farming can boost biodiversity, conserve water, and improve soil quality. These practices can lead to long-term sustainability, reduce reliance on chemical inputs, and increase resilience to climate change.
3. **Technological Innovations:** Advancements in technology offer significant opportunities to enhance food security and promote sustainable agriculture in India. Precision farming utilizes technologies like GPS and remote sensing to optimize the use of resources such as water, fertilizers, and pesticides, thereby improving productivity and sustainability. Major investments in biotechnology can yield pest-resistant and drought-resistant crop varieties.
4. **Education and Training:** It is vital to invest in the education and training of farmers concerning sustainable agricultural practices and food security. Agricultural universities and extension services can play a pivotal role in providing farmers with the necessary knowledge and skills. As a result, the adoption of sustainable practices can expand more widely when farmers are equipped with the right tools.
5. **Diversification and Value Addition:** Enhancing food security and economic resilience can be achieved by diversifying agricultural outputs and increasing the value of agricultural products. Encouraging farmers to cultivate a variety of crops, particularly those that are nutrient-dense and high-value, can lead to a more varied diet and increased income. Furthermore, farmers can unlock additional revenue streams through processing, packaging, and marketing their products.

A SUSTAINABLE AGRICULTURE AND FOOD SYSTEMS: POLICY AND MARKET ANALYSIS

The understanding of a policy and market analysis for sustainable agriculture and food systems assesses the manner in which governmental policies and market forces interrelate in the adoption of practices that are environmentally damagingly or treat social equity and food accessibility for present and future generations. Thus, considerations may include consumer preferences, incentives for farmers, and the most appropriate way to organize the supply chain throughout the food-production cycle. In India, a key initiative that has been launched toward sustainable agriculture is Paramparagat Krishi Vikas Yojana (PKVY), which promotes organic farming while developing the market infrastructure for sustainable products. However, an extensive market analysis shows that there are uphill battles to be faced-infrastructure, value chain development, and adequate support for the smallholder farmer to transition toward sustainable approaches; timescale incentives for the adoption of climate-smart agricultural activities; and inclusion of nutritious crops toward food security. Some key initiatives are:

1. PKVY (Paramparagat Krishi Vikas Yojana) Launched between November and October 2023, this central government program aims to label and endorse organic farming practices by improving the market access of certified organic products.^[12]
2. Rashtriya Krishi Vikas Yojana (RKVY) this initiative provides financial support for the implementation of eco-friendly technologies, the advancement of sustainable farming practices, and the enhancement of farmers' skills and knowledge.^[13]
3. National Mission on Sustainable Agriculture (NMSA): This mission concentrates on climate-resilient farming methods such as water conservation and integrated practices.^[14]

MARKET STUDY COMPLICATIONS

1. **Dispersed Market:** Smallholder farmers struggle to access larger markets due to insufficient structured connections for their sustainable produce.
2. **Decent Price Premiums for Sustainable Goods:** Market indicators are insufficient, and consistent efforts yield no benefits because there is a relative lack of consumer interest in premium sustainable products.
3. **Inadequate Infrastructure:** These post-harvest losses not only impact the availability of sustainable products in the market but also distract you and undermine the experience of the sustainable products you invest your limited resources in.

CONCLUSION

A "policy and market analysis" relative to agriculture and food systems sustainable trials how governmental policies and market forces come to bear on fostering practices that minimize environmental degradation, promote social equity, and assure food availability for both present and future generations. This analysis also takes into account the consumers' liking, incentives for farmers, and how best the supply chain should be organized along the entire food production process. In India, one of the significant schemes to push forward sustainable agriculture is the "Paramparagat Krishi Vikas Yojana" (PKVY), which aims at organic farming while enhancing market development for sustainable products. However, from a market perspective, better infrastructure, value addition at various points of the value chain, and adequate support for smallholder farmers to transition toward sustainable methods are the dire need, including incentives for the adoption of climate-smart agricultural practices and promotion of nutritious crops for food security. Some significant initiatives are:-

Over the years, India has undergone considerable growth in agriculture, especially with the Green Revolution, the Ever-Green Revolution, and developments in biotechnology and precision agriculture. However, some of the challenges affecting the growth of the agricultural sector are climate change, resource depletion, fragmented landholding, and lack of infrastructure. Such issues threaten to maintain agricultural operations and food security for an ever-growing population in India. The study stresses that sustainable agriculture carries a great deal of importance for solving the issues. These include agro forestry, organic farming, and integrated pest management with the potential to enhance biodiversity, promote soil health, and reduce dependency on fossil-based inputs. Similarly, technological advancements, policy-level reforms, and farmer education constitute a backbone for enhancing resilience and achieving long-term food security. The alignment of sustainable agriculture with SDGs of the United Nations, mainly SDG 2 of Zero Hunger, lays the foundation for its key contribution toward global goals on poverty alleviation, environmental sustainability, and equitable growth. Despite having attained great milestones, there are exigent concerns of holistic policy approaches, market reforms, and active community involvement in addressing the threats to sustainable agriculture. Addressing these issues would provide food security to India while focusing its efforts on fighting climate change and sustainable development.

SUGGESTIONS

Building on India's potentially space-specific applications in agriculture and food systems, there are some recommendations loaded with potential to improve their foundation and functioning:

1. Develop climate-resilient infrastructure such as micro-irrigation systems and solar-powered pumps to optimize resource usage. Government grants and public-private partnerships can make these technologies accessible to smallholders.
2. Encourage agroecological zoning to match crop types with regional climatic and soil conditions. This approach ensures optimal land use while conserving water and minimizing the environmental footprint.
3. Expand training programs through agricultural universities and Krishi Vigyan Kendras to educate farmers on climate-smart agriculture. Hands-on demonstrations and region-specific modules can bridge the gap between knowledge and practice.
4. Incentivize farmer producer organizations (FPOs) to aggregate sustainable produce and negotiate better market terms. Linking FPOs with e-commerce platforms can also widen market reach and improve price realization.
5. Integrate sustainable agriculture goals with local panchayat and municipal development plans. Localized planning will ensure better coordination, resource allocation, and accountability for long-term sustainability outcomes.
6. Invest in biotechnological R&D for crops that are both nutrient-rich and stress-tolerant. These innovations can enhance both nutritional security and agricultural resilience under changing climatic conditions.
7. Mandate sustainability labeling and certifications for agricultural products to create consumer awareness and generate market premiums for eco-friendly goods. Retail partnerships can amplify the reach of certified products.
8. Promote decentralized storage and cold chain facilities at the village level to reduce post-harvest losses and improve market access. This is especially critical for perishable and high-value crops grown using sustainable methods.
9. Revise crop subsidy policies to support sustainable practices such as organic farming and crop diversification. Redirect financial incentives from chemical-intensive methods to ecologically responsible farming to encourage long-term adoption.
10. Strengthen monitoring and evaluation mechanisms for government schemes like PKVY and NMSA. Regular impact assessments and beneficiary feedback should guide necessary reforms and reallocations.

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