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SUSTAINABLE AGRICULTURE AND FOOD SYSTEM IN INDIA: CHALLENGES AND OPPORTUNITIES

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ABSTRACT

India has recently been experiencing a rapid transformation as it approaches the status of a developed nation, potentially surpassing others in this regard sooner than expected. Nevertheless, this progress has sparked concerns due to the country's increasing population, prompting experts to advocate for "sustainable development" to ensure that the nation's achievements remain accessible for future generations, a cause that has garnered significant attention in recent years. While various sectors continue to thrive, agriculture has consistently served as the foundation of the Indian economy; thus, to establish a robust agricultural system, the concept of sustainable agriculture has been emphasized heavily in recent times.

The primary aim of sustainable agriculture is to alleviate hunger, poverty, and malnutrition for the expanding population of the nation while also ensuring environmental well-being. In a country like India, food security has become a top priority due to the rapid population growth. The issues of sustainable agriculture and food security have emerged as significant concerns in the twenty-first century. The Green Revolution has been crucial in achieving high food productivity, but it has also resulted in soil and water pollution, climate change, and a decrease in biodiversity. As a result, meeting the food needs of the population while protecting the environment presents two major challenges for the agricultural sector. Therefore, sustainable agriculture must adopt comprehensive approaches and demonstrate adaptability and flexibility over time to adequately address the increasing demands for food production. This article aims to raise awareness about food security and to outline the challenges and opportunities associated with it for the benefit of humanity.

Key words: Sustainable Agriculture, Food Security, Environment, Poverty, Population.

INTRODUCTION

Agriculture represents one of the largest private sectors in India, significantly influencing GDP and employment figures. It serves as a foundation for sustainable economic progress by ensuring a balanced utilization of natural resources. Farming is a primary economic force in rural regions, where nearly two-thirds of the Indian population relies on it; thus, the sector's performance is closely tied to the overall economy, as well as employment and poverty rates. Given urbanization, industrial growth, and limited land resources, India must focus on enhancing productivity to achieve expansion in agriculture. Growth within the agriculture sector has been shown to boost incomes for the poorest individuals by two to four times more than growth experienced in other sectors. The agricultural sector's steady performance is crucial for India, as it secures food availability for a population of 1.3 billion and its increasing numbers. As of 2019, there were 93.094 million

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agricultural households in rural India, providing about 54.0 percent of all agricultural households. Furthermore, agriculture accounts for approximately 15.4% of total GDP in India [1], according to the estimated number of rural households, addressing the dietary needs of a growing population.

The notion of food security has evolved significantly over the decades. During the 1970s, it was primarily concerned with food supply, emphasizing increased food production while also improving distribution methods. It was found that enhancing the purchasing power of vulnerable groups served as an effective safeguard against food insecurity. We believe that at this stage of development, in addition to improving calorie security for the impoverished and achieving overall food grain security, India should broaden its focus to encompass nutritional security for its population. With this perspective, our current study proposes an expanded definition of food security. For the past fifty years, the nation has successfully avoided famines. However, leading up to the mid-1960s, chronic food grain shortages were commonplace in the Indian economy. This consistent failure to supply enough food to meet the rapidly increasing demand forced the government to frequently rely on large-scale imports and implement food controls. Subsequently, a new agricultural strategy, known as the Green Revolution, was launched to boost domestic food grain production. By the early 1980s, India had attained a significant level of self-sufficiency in food grain production, thereby achieving macro-level food security, albeit not more than that.

SIGNIFICANCE OF STUDY

This article focuses primarily on India's agricultural practices, particularly regarding food grains and the food security framework, and explores how to manage these sustainably amidst the present challenges, considering that a significant portion of India's population, approximately 42.83 percent [2], is directly or indirectly engaged in the agriculture sector, which encompasses a substantial part of the country's land area. The significance of studying sustainable agriculture and food systems in India can be outlined as follows:

1. *Food Security Challenges*: Given India's large population and the impacts of climate change, it is crucial to explore innovative methods for ensuring food security, making sustainable agricultural practices essential.
2. *Environmental Conservation*: Sustainable agriculture contributes to minimizing environmental damage, preserving natural resources, and enhancing ecosystem services, which aligns with India's global environmental objectives.
3. *Enhancing Rural Livelihoods*: Sustainable farming has the potential to increase income and improve the well-being of individuals in rural areas, which is vital for the nation's economy and overall development.
4. *Informing Policies and Practices*: Findings from this study can have a significant impact on shaping policies, designing programs, and refining practices in sustainable agriculture, aiding India in achieving its sustainability targets.

This research examines the present landscape of sustainable agriculture and food systems in India, with the goal of fostering a future that is more sustainable, equitable, and food-secure for the nation.

INDIAN AGRICULTURE: AN OVERVIEW

For the Indian economy, the agriculture sector stands out as the most significant. It supports the livelihoods of nearly two-thirds of the workforce in rural regions of the country. This sector provides jobs for 65 percent of the labour force, makes up about 27 percent of the GDP, and contributes 21 percent of total exports as well as supplying raw materials to various industries. Additionally, the livestock sector is estimated to contribute 8.4 percent to the

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nation's GDP and accounts for 35.85 percent of agricultural output. [3]

In India, roughly 75 percent of the population lives in urban regions and relies on agriculture, while approximately 43 percent of the land area is allocated for agricultural activities. Furthermore, the country's estimated food output is around 211.17 metric tons. [4]

ACHIEVEMENTS IN INDIAN AGRICULTURE

Indian agriculture has experienced remarkable progress over the years, evolving from traditional subsistence farming to a more efficient and technologically enhanced system. The following is an overview of the major accomplishments:-

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 avoided famine. However, the rapid population growth that followed independence has created a dire situation for millions in the country. In response, the Indian government has implemented extensive food policies. These policies include various measures undertaken over time to

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boost domestic food grain production and maintain reasonable price stability. The framework of India's food policies is built upon two main principles: first, to defend the interests of producers, and second, to protect consumers' interests. This dual focus is clearly illustrated in the objectives of India's national food policy, which are outlined below: -

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

India's economy is largely cantered around agriculture. Approximately 54.6% of the entire workforce is involved in agricultural and related activities, contributing to 17.8% of the nation's Gross Value Added (GVA) for the fiscal year 2019-20 (at current prices). Roughly 57.8% of households in rural areas participate in agricultural work. [6] According to the Land Use Statistics from 2016-17, the total geographical area of the country is 328.7 million hectares, with 139.4 million hectares designated as the net sown area and 200.2 million hectares considered the gross cropped area, which reflects a cropping intensity of 143.6%. The net area sowed accounts for 42.4% of the entire region. The area that is irrigated amounts to 68.6 million hectares. [7] Grain production in the nation stands at an estimated of record 291.95 million tons, according to second advance estimates for 2019-20. [8] As per projections by the Indian Council for Agricultural Research (ICAR), the demand for food grains is expected to reach 345 million tons by 2030. The overall productivity of many agricultural products in India remains relatively low.

Key challenges facing Indian agriculture include that 85% of land is categorized as marginal and small farms, typically under 2 hectares [9]. Access to credit is limited, technology and mechanization are used sparingly, and infrastructure is inadequate, which leads to ineffective weather use and unsuitable marketing and distribution channels for high-value crops. Addressing these challenges necessitates innovative technological solutions grounded in strong scientific principles, community involvement, as well as robust infrastructure and supportive policies.

CHALLENGES IN THE AGRICULTURE SECTOR

As we all recognize, agricultural methods differ globally, implying that each nation has its unique strategies for sustainable farming, which may also vary within different regions of the same country. Consequently, Indian agriculture faces numerous challenges, both locally and internationally, some of which are outlined 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.

6. Implementing biological science-based technologies and approaches can help increase food grain production sustainably.

7. Enhancements in crop management and agricultural practices are needed.

8. Various strategies must be adopted based on different regions and situations.

9. 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.

10. One of the most significant challenges for sustainable agriculture remains the issue of climate change.

ROLE OF AGRICULTURE IN ACHIEVING SUSTAINABLE GOALS

The Agenda for Sustainable Development, introduced by the UN in 2015, serves as a framework for promoting peace and prosperity. The United Nations Development Program established 17 Sustainable Development Goals aimed to be fulfilled by 2030. These goals focus on eradicating poverty while enhancing health and education, diminishing inequality, and combating climate change through global collaboration. It is imperative that all member states work together to realize these objectives, as global development is at risk following the shift from the Millennium Development Goals. Agriculture plays a crucial role in achieving the SDG targets due to its potential to ensure food security.

It also addresses hunger and malnutrition while alleviating poverty along with the consumption of water and energy—all of which are interconnected with climate change and the economy. On a wider scale, agriculture contributes to better living conditions in impoverished rural regions, enhancing nutritional security. Among all the Sustainable Development Goals, SDG 2 (which focuses on eliminating hunger and ensuring food and nutritional security) is perhaps the most daunting yet achievable goal through sustainable agriculture practices.

Sustainable agriculture, as outlined by Dobermann, must include at least six essential components:-

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.

Analysis of surface temperatures throughout the country shows a steady increase over time, indicating a warming trend that mirrors the rise in global average temperature. This global temperature increase directly impacts the hydrologic cycle by enhancing the evaporation

of surface water and the transpiration from vegetation. As a result, these alterations can affect the quantity, timing, and intensity of precipitation, which in turn influences the flux and storage of water in both surface and subsurface environments (such as lakes, soil moisture, and groundwater). This situation leads to the degradation of agricultural land and results in food shortages. The IPCC Fourth Assessment Report states that by the mid-20th century, there was over 90 percent likelihood that global warming is attributed to human-made greenhouse gases (GHGs). In the absence of policy action, the average global temperature is projected to increase by between 1.1°C and 2.9°C in the IPCC's lowest emissions scenario and between 2.4°C and 6.4°C in the highest scenario from 2090 to 2100, compared to the 1980-1999 period. [10]

The initial half of the 20th century experienced two periods without any droughts, specifically from 1921 to 1930 and from 1931 to 1940. In contrast, the 21st century has already witnessed three drought-free decades within its first ten years. Considering the decade from 2010 to 2020, the decade from 2020 to 2030 has already had three years without droughts. Up to this point, there have been no drought occurrences in the country. If we disregard the years 2020 to 2030 and focus on the five-year span from 1991 to 1995, that time period was also free of droughts. The droughts that occurred in 1965-66, 1987, 1999-2000, 2002-2003, and 2013-14[11] were managed effectively and did not result in severe food insecurity in India, largely due to the maintenance of buffer food stocks in the country. However, food production in India continues to rely heavily on rainfall and its distribution. The primary source of water is the south-west summer monsoon, which accounts for 78 percent of the annual rainfall and is crucial for crop irrigation across the nation. It is important to note that the yield of rain-fed crops suffers significantly during years with considerably low rainfall. Furthermore, it is worth mentioning that the 2014 drought affected the same area where the previous four major droughts occurred.

OPPORTUNITIES TO SUSTAINABLE AGRICULTURE AND FOOD SECURITY

Sustainable farming practices and reliable access to food are essential for maintaining environmental well-being, economic resilience, and social fairness. Listed below are the main opportunities that can assist India in reaching these objectives:-

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

A "policy and market analysis" for sustainable agriculture and food systems assesses how governmental policies and market dynamics influence the adoption of practices that minimize environmental damage, promote social equity, and ensure food accessibility for both current and future generations. This analysis considers factors such as consumer preferences, incentives for farmers, and the optimal organization of the supply chain throughout the food production cycle. In India, a key initiative aimed at advancing sustainable agriculture is the *"Paramparagat Krishi Vikas Yojana"* (PKVY), which focuses on organic farming while enhancing market development for sustainable products. Nevertheless, a thorough market analysis highlights the necessity for better infrastructure, value chain enhancements, and adequate support for smallholder farmers to transition toward sustainable methods, including incentives for adopting climate-smart agricultural practices and promoting the inclusion of nutritious crops to bolster food security. Here are some notable initiatives:-

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

4. **Dispersed Market:** Smallholder farmers struggle to access larger markets due to insufficient structured connections for their sustainable produce.
5. **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.
6. **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 & SUGGESTIONS

The transition of agricultural technologies should shift from focusing on manufacturing efficiency to prioritizing profitable and sustainable farming practices. The current conditions are increasingly favourable for the

advancement of sustainable agriculture. Opportunities that have emerged are enlightening farmers across various sectors, including dairy, poultry, cattle, and fisheries. Now is the appropriate moment to explore viable and promising practices that not only yield economic rewards but are also essential for fostering economic sustainability. Agriculture is a fundamental component of the Indian economy, playing a vital role in GDP contribution, job creation, and ensuring food security.

Over the years, India has achieved significant improvements in agricultural productivity, especially through initiatives like the Green Revolution, the Ever-Green Revolution, and advancements in biotechnology and precision agriculture. Nonetheless, the sector encounters multiple hurdles such as climate change, depletion of resources, fragmented landholding, and insufficient infrastructure. These issues pose a threat to the sustainability of agricultural practices as well as to the food security of India's expanding population. The research emphasizes the vital importance of sustainable agriculture in tackling these challenges. Practices such as agro forestry, organic farming, and integrated pest management can boost biodiversity, enhance soil health, and minimize reliance on non-renewable resources. Furthermore, innovations in technology, reforms in policy, and educational initiatives for farmers are crucial for building resilience and ensuring long-term food security.

The alignment of sustainable agriculture with the United Nations Sustainable Development Goals (SDGs), particularly SDG 2 (Zero Hunger), highlights its crucial role in reaching global objectives related to poverty alleviation, environmental sustainability, and equitable growth. Despite the advancements achieved, there is an urgent need for holistic policy strategies, market reforms, and active community involvement to address the obstacles to sustainable agriculture. By tackling these concerns, India can secure its food future while also playing a part in global initiatives aimed at fighting climate change and advancing sustainable development.

SUGGESTIONS

1. Strengthen Policy Frameworks:

iv. *Incentivize Sustainable Practices*: Offer financial incentives, subsidies, and tax reductions to farmers who implement sustainable methods such as organic farming, agro forestry, and water conservation.

v. *Support Smallholder Farmers*: Create policies aimed at enhancing access to credit, technology, and markets for small and marginal farmers, who represent a substantial part of India's agricultural workforce.

vi. *Promote Climate-Resilient Agriculture*: Broaden initiatives like the National Mission on Sustainable Agriculture (NMSA) to promote the use of climate-smart practices and technologies.

2. Enhance Technological Adoption:

i. *Invest in Precision Agriculture*: Encourage the use of GPS, remote sensing, and IoT-based technologies to improve resource efficiency and boost productivity.

ii. *Leverage Biotechnology*: Speed up research and development in genetically modified crops that can withstand pests, diseases, and drought while ensuring safety and accessibility for farmers.

iii. *Digital Platforms for Farmers*: Create mobile applications and online platforms that offer up-to-date information on weather, market prices, and best farming practices.

3. Improve Infrastructure and Market Access:

i. *Reduce Post-Harvest Losses*: Invest in cold storage facilities, transportation

infrastructure, and processing units to decrease losses and enhance the availability of sustainable products in markets.

ii. *Create Market Linkages*: Set up organized market connections for smallholder farmers to tap into larger markets and receive fair compensation for their produce.

iii. *Promote Value Addition*: Support the processing, packaging, and branding of agricultural products to elevate their market value and generate extra income streams for farmers.

4. Focus on Education and Training:

i. *Farmer Training Programs*: Organize workshops and training sessions to inform farmers about sustainable practices, resource management, and climate resilience.

ii. *Strengthen Agricultural Extension Services*: Expand extension services to deliver on-the-ground support and guidance to farmers in remote locations.

iii. *Collaborate with Agricultural Universities*: Partner with academic institutions to develop educational programs and research initiatives focused on sustainable agriculture and food security.

5. Promote Diversification and Nutritional Security:

i. *Encourage Crop Diversification*: Inspire farmers to grow a range of crops, including high-value and nutrient-enriched foods, to improve dietary diversity and stabilize income.

ii. *Support Livestock and Fisheries*: Incorporate livestock and fishery systems into agriculture to provide additional income and nutrition sources for rural families.

6. Address Climate Change Challenges:

i. *Develop Early Warning Systems*: Establish systems to track and forecast extreme weather events, allowing farmers to take precautionary actions.

ii. *Promote Water Conservation*: Advocate for the use of drip irrigation, rainwater harvesting, and other water-saving practices to alleviate the effects of water scarcity.

iii. *Strengthen Disaster Management*: Enhance the ability of farmers and local communities to manage droughts, floods, and other climate-related emergencies.

7. Foster Public-Private Partnerships:

i. *Collaborate with Private Sector*: Involve private companies in research, development, and the execution of sustainable agricultural technologies and practices.

ii. *Encourage Corporate Social Responsibility (CSR)*: Leverage CSR funds to back projects related to sustainable agriculture, farmer training, and rural development initiatives.

8. Raise Awareness and Consumer Support:

i. *Promote Sustainable Products*: Initiate campaigns to inform consumers about the advantages of sustainably produced food and motivate them to support such goods.

ii. *Certification and Labelling*: Create certification programs and labels for sustainable products to enable consumers to make informed decisions and reward farmers for their commitment to sustainable practices.

By implementing these suggestions, India can transition towards a more sustainable, resilient, and equitable agricultural system. This will not only ensure food security for its population but also contribute to global efforts in achieving the

Sustainable Development Goals and combating climate change.

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