

India's Agriculture Sector's Journey towards Sustainable Development Goals: Assessing Governmental Interventions and Sectoral Outcomes

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Abstract The Sustainable Development Goals (SDGs) comprise a set of 17 global objectives established by the United Nations to tackle urgent worldwide challenges, including poverty, inequality, climate change, and environmental degradation. Numerous SDGs are directly linked to the realms of food and agriculture. SDG 2, named Zero Hunger, focuses on ending hunger, achieving food security, enhancing nutrition, and promoting sustainable agriculture. SDG 12, Responsible Consumption and Production, addresses the need for sustainable food systems and the reduction of food waste. SDG 13, Climate Action, underscores the connection between agriculture and efforts for climate change mitigation and adaptation. Additionally, SDG 15, Life on Land, emphasizes the significance of safeguarding terrestrial ecosystems and biodiversity, often impacted by agricultural practices. These goals collectively highlight the pivotal role of food and agriculture in realizing broader sustainable development objectives. India, with its significant agrarian base, stands at the forefront of addressing Sustainable Development Goals (SDGs) in the agriculture sector. This paper delves into the multifaceted challenges encountered by the Indian economy concerning SDGs in agriculture and examines the diverse array of initiatives introduced by the government to attain these goals. Through a comprehensive review of literature and policy analysis, this paper identifies

key areas such as poverty alleviation, food security, sustainable land use, water management, and rural livelihoods, among others, where concerted efforts are required to achieve the SDGs. Furthermore, it explores the intricate interplay between socio-economic factors, environmental sustainability, and technological advancements in shaping the trajectory of Indian agriculture. By critically evaluating government interventions, including policies, programs, and schemes, the paper elucidates their effectiveness, gaps, and potential areas for improvement. Insights from this research aim to inform policymakers, stakeholders, and practitioners in designing holistic strategies to navigate the complexities of sustainable development in Indian agriculture.

Keywords Sustainable Development Goals (SDG), No Poverty, Zero Hunger, Natural Farming, Decent Work and Economic Growth, Responsible Consumption and Production, Climate Action, Agriculture, Government Interventions

1. Introduction

India's agriculture industry is essential to the country's

economy and is closely related to several of the Sustainable Development Goals (SDGs) set forth by the UN. By 2030, these SDGs will have provided a framework for tackling world issues and advancing sustainable development. Agriculture holds paramount significance for both livelihoods and the overall economic stability of India. The growth of agriculture is influenced by a multitude of factors, spanning chemical and biological aspects, as well as technical considerations that are intricately tied to the market demand. The dynamic interplay of these factors underscores the complexity of sustaining and enhancing agricultural practices, making it imperative to address a diverse range of challenges for the prosperity of this crucial sector [1]. The crucial role of the agricultural sector in economic development and sustainable livelihoods is recognized both at the continental and global levels. This acknowledgment is evident through initiatives spearheaded by the African Union Commission (AUC), aligning with the Sustainable Development Goals (SDGs) and complementing the national development endeavors of member states [2]. Increasing agricultural income and production is a major way to reduce poverty by providing sustainable means of subsistence. Combining conventional knowledge with contemporary farming methods can increase agricultural output, improve the health and condition of the soil, and promote socioeconomic balance [3]. India faces challenges related to food distribution and accessibility and implementing sustainable farming practices is imperative in guaranteeing a steady and sufficient supply of food for the rapidly growing populace. A sharp increase in consumer demand for goods has been placing extraordinary strain on India's food and agricultural supply lines since late 2020. Due to the increased demand, the e-commerce industry has undergone tremendous changes. Food producers, merchants, distributors, importers, and e-commerce companies have worked together to create innovative distribution networks. Notably, well-known applications for food delivery and taxi aggregation, such as Swiggy, Uber, and Zomato, have partnered with conventional and contemporary retail businesses to enable grocery delivery [4].

India's largest industry for employment is agriculture, and developing agribusinesses, adding value, and implementing sustainable methods can all help to increase employment and promote economic growth. Although agriculture generates nearly two-fifths of all employment opportunities, its contribution to the GDP has been steadily decreasing over time. [5]. The agricultural industry still contributes over one-fifth of the nation's total income, although it plays a smaller part in overall GDP [6]. It is crucial to adopt sustainable farming practices, like organic farming and wise resource management, to encourage conscientious consumption and production and reduce the environmental effects of agriculture. The depletion of essential natural resources that are necessary for maintaining agricultural systems is one of the major costs associated with growth-oriented agricultural policies, as

numerous macro and micro studies analyzing their consequences have repeatedly shown [7]. Society faces dual challenges: first, embracing sustainable agricultural practices to ensure present and future food needs, and second, achieving a twofold increase in food production by 2050 to meet the growing global demand [8]. Public investment in bio inputs is much below the set threshold, in contrast to the large subsidy provided for chemical inputs. In India, the total allotment for organic inputs is just \$176 million, while the subsidy for chemical fertilizers is \$18,666.67 billion [9]. However, newer government programs such as the Paramparagat Krishi Vikas Yojana (PKVY) aim to incentivize farming units to use bioinputs by providing resources and financial support.

The national emphasis on elevating agricultural productivity should underscore the importance of directing efforts toward investing in the sustainable management and utilization of water and energy resources in agriculture [10]. This strategic approach is essential for realizing not only sustainable economic growth but also for fostering resilient livelihoods. Adopting climate-smart agricultural practices is crucial because of agriculture's vulnerability to climate change and its role in greenhouse gas emissions. These methods not only increase farmers' resilience but also lessen the sector's influence on climate change. Afforestation, conservation programs, and sustainable land management practices all play a vital role in maintaining biodiversity and the general well-being of terrestrial ecosystems. The agricultural industry requires cooperation between local communities, NGOs, governments, and businesses in the private sector to achieve sustainable development. Collaborations are essential for enabling information sharing, technology transfer, and resource mobilization toward the shared objective of resilient and sustainable agriculture in the future.

Significant reforms and strengthening of the nation's agricultural research and extension systems are necessary for India's agricultural development to be revitalized. A one-size-fits-all approach is insufficient given the large and diversified terrain of India, which includes a range of agro-climatic and economic circumstances. Agricultural research and extension must undergo a dramatic transformation to achieve agricultural development. These services are essential in converting the government's goals into concrete actions that advance agricultural growth.

2. Review of Literature

A multifaceted strategy is needed to achieve sustainable growth in the agriculture sector, including regulatory interventions, technical advancements, and a shift in traditional behaviors towards sustainability. According to the research, striking a balance between employment, productivity, and environmental sustainability is crucial.

The idea of Agriculture 4.0, which is a component of the Industrial Revolution's fourth wave, is covered in this

article. It draws attention to the three main challenges that the agriculture industry faces: preserving the environment, generating income, and increasing production. The essay highlights how digital technologies might provide creative ways to increase agricultural productivity while lowering related hazards [11]. To address the difficulties of the twenty-first century, agriculture must undergo a revolutionary transformation, as discussed in this article by Prof. Ramesh Chand [12], a member of the Indian government's Niti Aayog. It emphasizes how vital agriculture is to maintaining food security and nutrition, adjusting to and reducing the effects of climate change, and making sustainable use of vital resources like land, water, and energy. This paper offers a framework for examining how governments might enhance agricultural innovation. It might be a useful tool for comprehending government actions in the field of agriculture [13]. This source offers important insights into how the Sustainable Development Goals (SDGs) affect people and natural resources, even if its primary concentration is on forests. It highlights how important it is to keep learning from and adjusting the SDG implementation process [14]. This article examines the relationship between India's agriculture industry and Sustainable Development Goal 1 (No Poverty), focusing on how increased agricultural output might help improve rural areas and reduce poverty. Moreover, it explores the pivotal function performed by Indian agriculture in promoting Sustainable Development Goal 2 (Zero Hunger) utilizing enhancing food security and availability. To highlight the significance of implementing sustainable measures to lessen the negative effects of climate change, the article highlights the essential link between India's agricultural practices and Sustainable Development Goal 13 (Climate Action). The essay also clarifies the extensive effects of sustainable agriculture methods on several Sustainable Development Goals. The paper provides insights into the obstacles that prevent the industry from reaching its full potential, even in light of these noteworthy contributions. The article concludes by outlining potential directions and suggesting strategies to unleash the agricultural sector's unrealized potential in India, opening the door for significant progress towards the accomplishment of the Sustainable Development Goals [15]. This study examines the problems surrounding agricultural production trends, specifically as they pertain to specific crops farmed in India's main states. Crop productivity's sustainability problem is becoming more and more apparent. The 1990s saw a decline in productivity from the 1980s, which presented a challenge to academics trying to improve the technology index and change the production function. The study's conclusions have important policy ramifications for the nation's food and household nutritional security as well as the availability of agricultural commodities. It is critically necessary to boost agricultural investments, particularly in R&D, to promote TFP growth [16]. Sengupta [17] examines and addresses the topic of sustainable development in Indian agriculture. In addition,

it seeks to draw comparisons between the traditional and sustainable agricultural systems in terms of ecological, economic, and social sustainability. Improving production, creating jobs, and giving the impoverished sections of the population a source of income are the main concerns of agricultural development. India is lagging in the adoption of contemporary technologies, and its agricultural methods are far too impromptu and non-scientific. The revival of cooperative institutions, bettering rural financing, research, human resource development, trade and export promotion, land reforms, and education are some of the fundamental concerns for the growth of the Indian agriculture industry. To accomplish the targets at the national and local levels, the SDGs and regional and continental commitments in the agriculture sector must be implemented, monitored, and evaluated [2]. To promote the convergence of climatic, agricultural, and sustainable development policies in the European Union (EU), a new set of metrics for evaluating sustainability in agriculture has been unveiled. At both the regional and national levels in the EU, this suggested framework makes it easier to integrate agriculture-related sustainability concerns with important goals like environmental priorities, sustainable development goals, and climate measures. This article's main contribution is the way it links the goals of rural policy to more general sustainability objectives, such as environmental and climate change mitigation strategies. Through a thorough system of indicators, the novel framework for assessing agricultural sustainability that is provided here makes it possible to keep an eye on these relationships [18].

3. Objective of the Study

To analyze the government initiatives to achieve the SDG goals in the agriculture sector.

To evaluate the past and present agricultural performance in terms of production levels, employment generation, contributions to economic growth, the efficiency of food distribution channels, and the adoption of climate-smart agricultural practices and propose a model to attain the sustainable development goal of 2030.

4. Methodology

A comprehensive review of the existing literature was undertaken across several prominent databases, including Scopus, Web of Science, ProQuest, AGRICOLA, AGRIS, and via Google search engines. Furthermore, relevant data was sourced from the annual reports of the Ministry of Agriculture and Farmers Welfare, Government of India. The search strategy employed keywords such as Sustainable Development Goals (SDG), No Poverty, Zero Hunger, Decent work and economic growth, Responsible consumption and production, Climate Action, Agriculture,

Government Interventions, with a specific focus on the Indian context. Identified articles were meticulously compiled, ensuring elimination of duplicates, and rigorous quality control measures were applied. Two researchers independently reviewed the chosen articles to ensure precision and dependability. Apart from academic sources, valuable insights were gleaned from government ministry websites and annual reports, providing the foundational framework for the results and discussion section.

5. Results & Discussions

Using sustainable farming practices is essential to maintaining food supply over the long run, protecting the environment, and promoting economic stability. These methods are essential for maintaining biodiversity, reducing greenhouse gas emissions, reducing water pollution, and maintaining healthy soil. Sustainable farming practices help mitigate the negative effects of agriculture on ecosystems and climate change while also promoting the welfare of present and future generations by preserving the quality of agricultural resources.

Since the inception of the UN-SDGs, global developmental policies have persistently aimed to align sectoral growth objectives with sustainability principles. The SDGs, along with their associated targets and indicators, provide a structured framework for pursuing lasting well-being across generations while respecting environmental boundaries. The sustainable transformation of agri-food systems emerges as a pivotal catalyst with the potential to substantially impact progress across a majority of the 17 Goals [19,20].

The Indian government has been actively developing comprehensive policies for the agriculture and food sector at the national and state levels in recent times. The goal of these policies is to improve the agri-food sector's sustainable growth by integrating strategies, innovations, technology, and finance strategic methods. The National Mission on Sustainable Agriculture, which is a significant initiative spearheading these efforts, is integrated into the 'National Action Plan on Climate Change. This goal focuses on components of sustainable agriculture, including diversification of livelihoods, nutrient management, soil health management, and efficient use of water.

Concurrently, several developmental reforms and programs are put into place to improve rural livelihoods, increase farmer incomes, and support the social sustainability of the agri-food industry. All farmer households receive direct income support through the PM-KISAN program, while drought-proofing strategies for Indian agriculture through water collection and

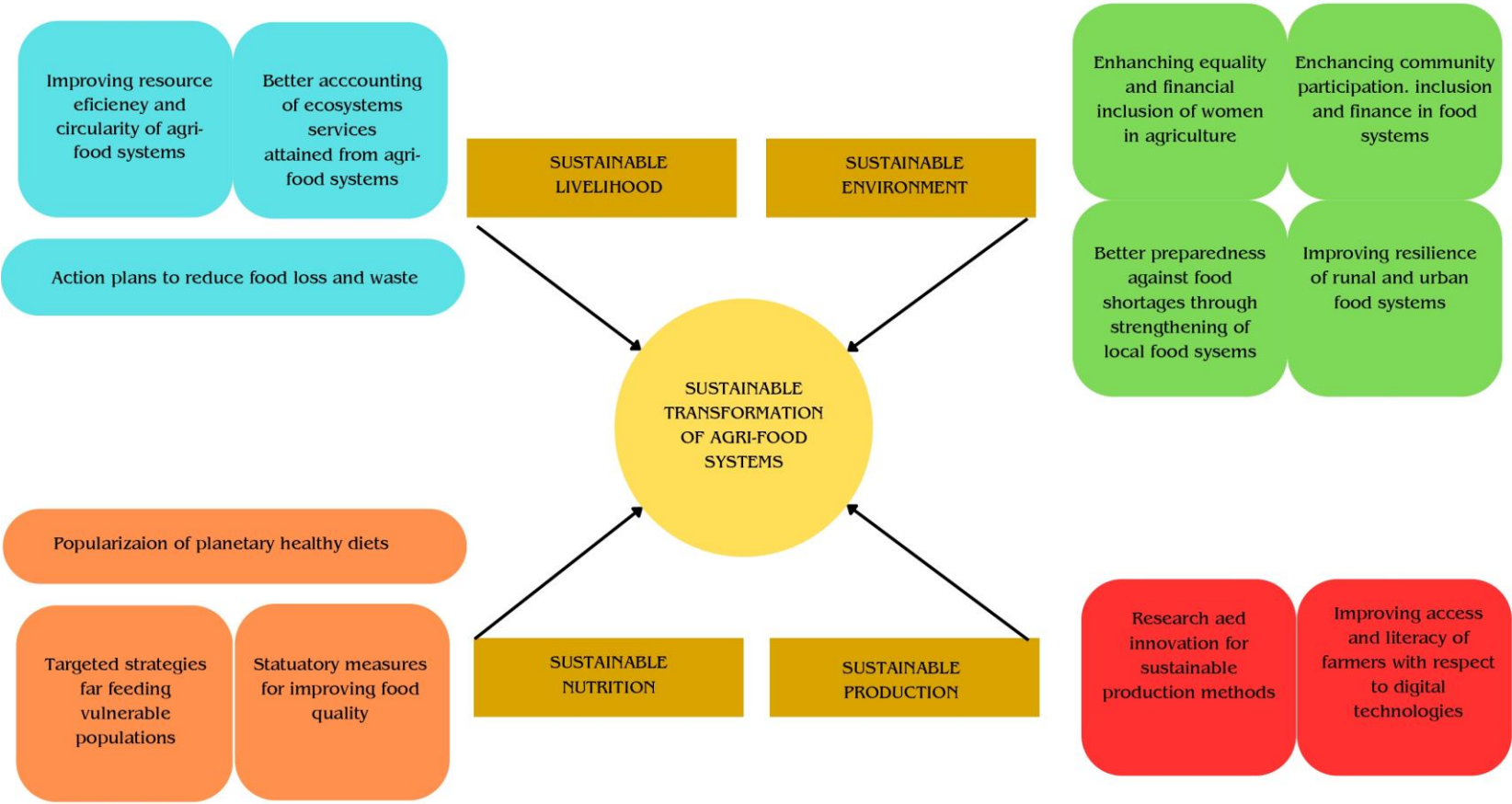
conservation are implemented under the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA). Through the Agri-Infrastructure Fund, there is also a significant push for the construction of agricultural infrastructure [21].

The national government sets minimum support prices for important agricultural commodities and steps into the market when prices drop below a certain point to guarantee farmers receive fair prices. While some programs are specifically designed to increase the production of horticulture crops, edible oils, and food grains, others, such as PM-FMBY, are designed to reduce the risk of crop failure for farmers. The purpose of the Agriculture Infrastructure Fund is to improve post-harvest management and farm-gate infrastructure [22].

The PM Kisan SAMPADA Yojana constitutes a comprehensive package designed to establish modern infrastructure and facilitate efficient supply chain management from the farm gate to the retail outlet. This initiative is poised to not only significantly enhance the growth of the food processing sector within the country but also to ensure improved returns for farmers. It represents a substantial stride towards the ambitious goal of doubling farmers' income, fostering extensive employment opportunities, particularly in rural areas. Moreover, the scheme aims to curtail agricultural produce wastage, elevate processing levels, and bolster the export of processed foods, contributing to the overall development of the agricultural and food processing industries.

By building decentralized solar-powered agriculture pumps and solarizing grid-connected pumps, the PM-KUSUM project further emphasizes resource efficiency and the production of renewable energy. The National Agricultural Research System offers vital technology to address supply-side problems in agri-food systems through national institutes, Krishi Vigyan Kendras, and State Agricultural Universities.

State development programs now incorporate a variety of initiatives and best practices, including those developed by the NICRA, unified farming systems, and organic farming research. The availability of fish and animal proteins has increased thanks to breeding practices, diagnostics, and livestock vaccinations. India runs one of the biggest farmer outreach programs to improve food production and resistance against biotic and abiotic challenges, thanks to its extensive network of Krishi Vigyan Kendras. This research delves into the perceived impacts of rural-urban interactions on the sustainable development of agriculture in Nigeria. The findings suggest that integrating rural-urban interactions into community development initiatives is essential for fostering sustainable agricultural growth [23].



Source: [24,25]

Figure 1. Sustainable Transformation of Agri-Food Systems

Furthermore, the nation oversees the biggest food distribution program established by the National Food Security Act (NFSA), meeting the nutritional needs of qualified adults and school-age children via the Mid-Day Meal (MDM) and Targeted Public Distribution System (TPDS) programs. Additionally, the third tranche of the Aatmnirbhar Bharat Scheme monies was allocated solely to agricultural reforms, such as the Pradhan Mantri Garib Kalyan Anna Yojana's (PMGKAY) free grain distribution to people negatively impacted by the COVID-19 pandemic. Figure 1 has pinpointed key focus areas aimed at steering the sustainable transformation of agri-food systems, aligning with the objectives of Agenda 2030.

India is pursuing comprehensive measures at the state and international levels with great vigor and urgency. These initiatives include policy declarations, stakeholder discussions, strategy execution, and raising awareness to turn the nation's agri-food industry into a sustainable business. Concurrently, these measures aim to promptly accomplish the objectives delineated by the United Nations Sustainable Development Goals (UN-SDGs).

6. Future Directions

Natural Farming

Agro-ecological methods such as Natural Farming can provide an affordable and environmentally friendly substitute. By improving yield, allowing for crop diversity, and providing access to a variety of income-generating crops and nutritious supplies all year round, this approach

can guarantee both food security and the absence of hunger. Natural farming's water-saving and ecological preservation features support water availability and sustainable management, as well as the reduction of CO₂ emissions at different points along the agricultural value chain [26].

Increasing Small-Scale Farmers' Productivity

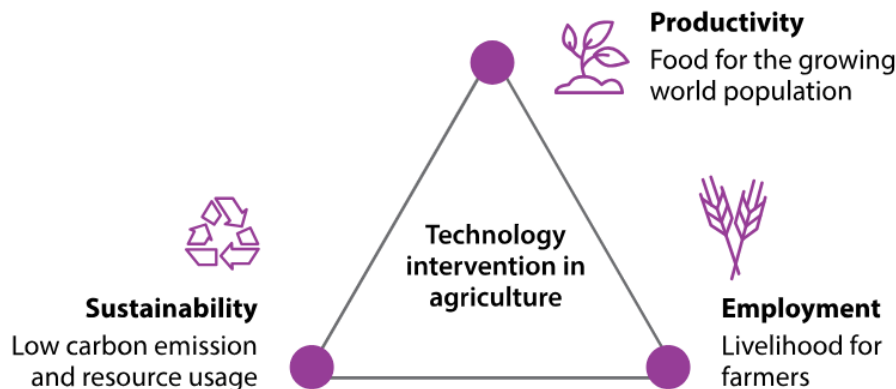
The government needs to concentrate on raising small-scale farmers' productivity. The agricultural production and incomes of small-scale food producers can be doubled by providing them with equal and secure access to land, other productive resources and inputs, expertise, financial services, markets, and opportunities for value addition and non-farm revenue [27].

Infrastructure Investment

The government intends to establish 10,000 farmer-producer organizations through the creation of an Agriculture Infrastructure Fund, which has a corpus of Rs 1 lakh crore [28].

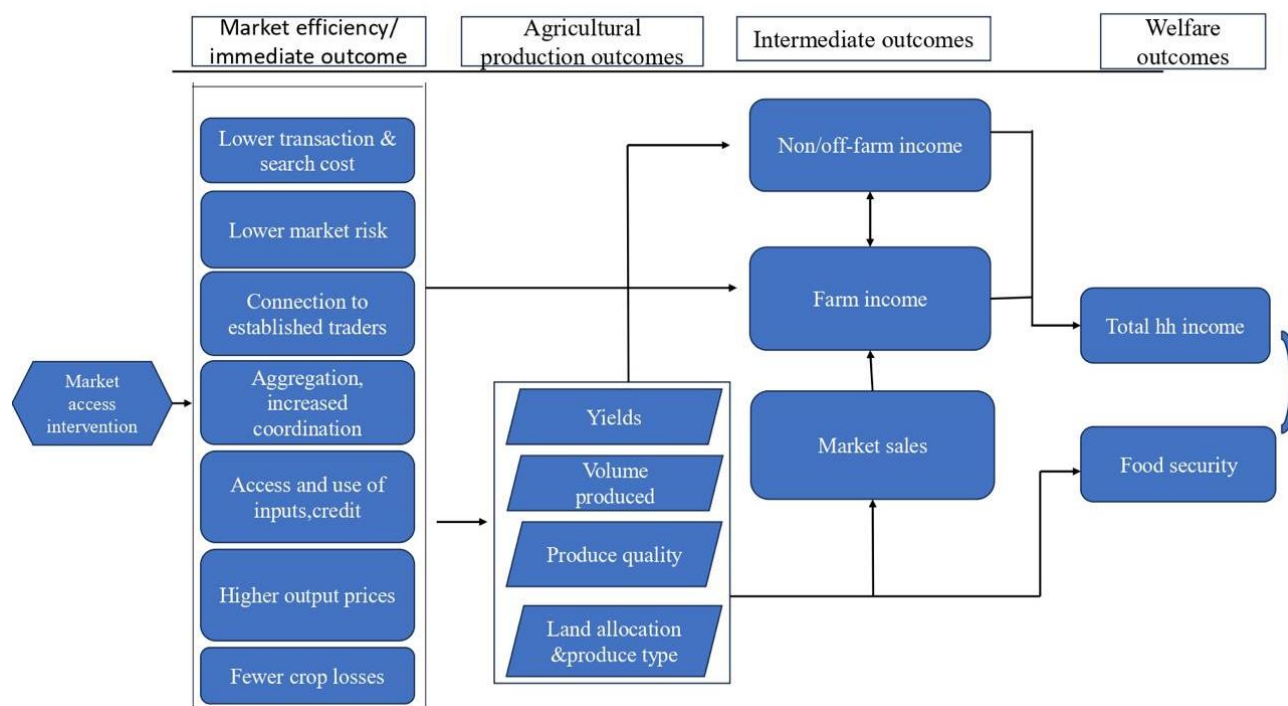
Precision Agriculture and Technology Adoption

Adopt precision farming with contemporary technology like AI, drones, and the Internet of Things to improve yield optimization, crop monitoring, and resource management. Encourage the application of intelligent agricultural methods to increase output, cut down on resource waste, and lessen the impact on the environment. How technology can balance the productivity, employment and Sustainability is showed in Figure 2.



Source: [29]

Figure 2. Technologies balance productivity, employment, and sustainability in India



Source: (Villar et al., 2023)

Figure 3. Conceptual model: Potential channels of effects

Agriculture hasn't yet adopted these technologies on a large scale in India, even though many other industries have. Given the fragmented structure of the sector, green farming methods will need to be adopted by over 25% of the world's population to ensure a sustainable future. Generally speaking, technological intervention in agriculture takes two forms: digital pathways that facilitate timely and important decision-making, and physical paths that automate operations using machinery. Data such as commodity pricing, weather patterns, and soil factors can be used by farmers to make decisions that will increase productivity and efficiency.

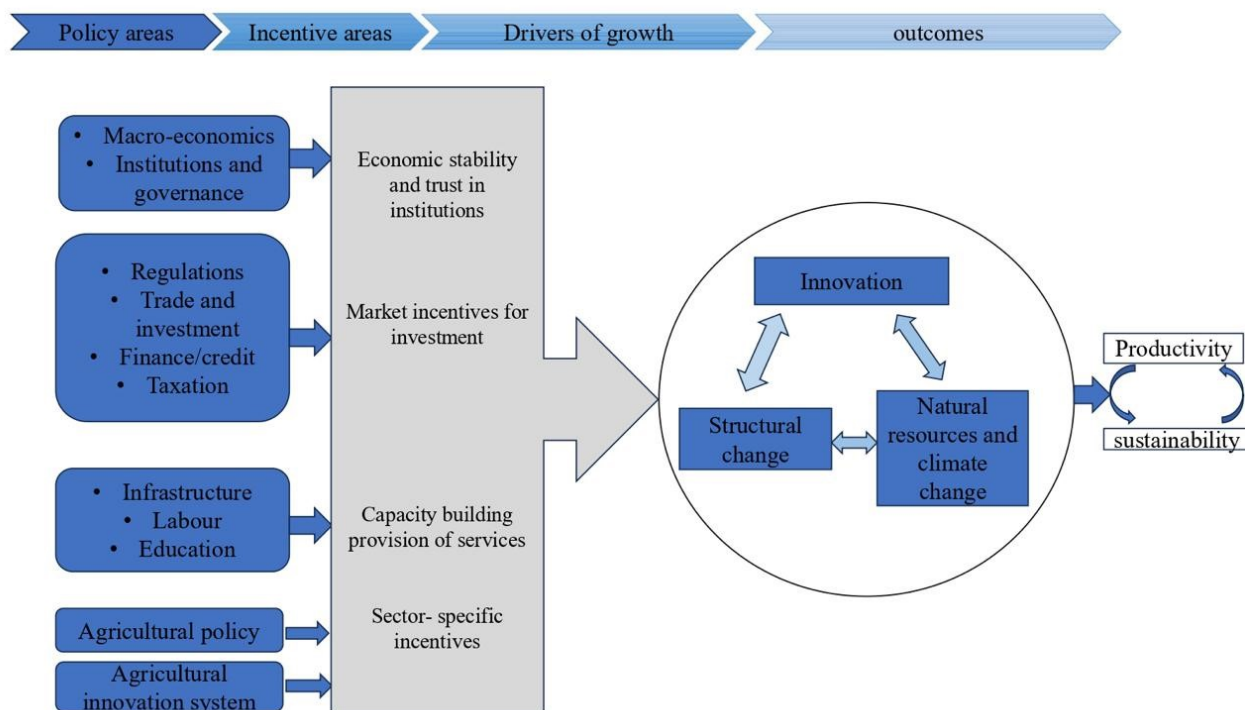
Access to Markets and Fair Trade: For farmers to have better market access and to minimize post-harvest losses, transportation and storage infrastructure should be improved. Encourage fair trade methods and guarantee that farmers are paid fairly for their produce. The review's theoretical framework is grounded in a larger body of literature that suggests interventions might improve market access by altering the way markets operate and reducing market inefficiencies that prevent farmers from accessing and participating in markets [30]. Improved connection or reduced search and transaction costs for farmers, reduced market risk for farmers, higher prices for farmers' produce, and so on are some examples of this and the same has been explained in the Figure 3.

Policy Reforms: Adopt and bolster laws that support land-use planning, natural resource management, and

sustainable agriculture. Make sure that laws support sustainable practices and are in line with the SDGs. Various policies and procedures that drive the innovation, productivity, and sustainability in the agriculture and agri-food sector are explained in Figure 4.

A multitude of policies exert influence on the performance of food and agriculture. With the increasing demand for policy evaluation across various countries, considerable strides have been taken in understanding the effects of agriculture-specific policies. However, there has been comparatively less focus on assessing the impact of general policies on the economic and environmental aspects of the agricultural sector. Yet, it's evident that establishing synergies between different policy areas, while also avoiding overlaps and contradictory signals, is crucial for achieving the dual objectives of enhancing productivity and ensuring environmental sustainability in food and agriculture.

Recognizing this need, the OECD has developed the "Food and Agriculture Productivity-Sustainability Framework" to assist countries in fostering a more conducive policy environment for food and agriculture (Figure 4). This framework identifies innovation, structural change, natural resource utilization, and climate change as the key drivers of productivity and sustainability. It also outlines the primary channels through which policy incentives affect these drivers.



Source: [13]

Figure 4. Policy drivers of innovation, productivity, and sustainability in the agriculture and agri-food sector

This framework comprehensively considers the entire spectrum of policy incentives and disincentives related to innovation, structural change, natural resource utilization, and climate change, all of which are recognized as drivers of productivity growth and sustainable resource management (Figure 4).

The primary channels, or incentive areas, encompass:

Economic Stability and Trust in Institutions

Macro-economic policies, justice, security, and property rights play pivotal roles in fostering an environment conducive to attracting long-term investment in the economy.

Private Investment

Transparency and predictability in the regulatory environment are vital for balancing the interests of investors and society. Policies related to business regulation, natural resource management, farm inputs, food products, trade, investment, finance, and taxation directly impact investment in agricultural and food sectors.

Physical and Human Capacity Building

Essential public services provision and skill development crucial for food and agriculture are influenced by infrastructure, rural development, labor, and education policies.

Agriculture-Specific Policies

These directly incentivize or disincentivize innovation, structural change, and natural resource use in agriculture. They encompass measures like market price support, input subsidies, direct payments to producers, and various services. Notably, the agricultural innovation system receives special attention within policies providing services, as it facilitates continuous innovation in technologies, practices, and organization, thereby promoting a more productive and environmentally sustainable food and agriculture sector.

7. Conclusions

In conclusion, the objectives of this study aimed to provide a comprehensive analysis of government initiatives geared towards achieving the Sustainable Development Goals (SDGs) within India's agricultural sector, alongside evaluating the nation's historical and current agricultural performance. Through an examination of production levels, employment generation, contributions to economic growth, efficiency of food distribution channels, and adoption of climate-smart agricultural practices, a nuanced understanding has been gained.

The findings underscore the need for strategic interventions to bridge existing gaps and propel the agricultural sector towards sustainable development by 2030. Proposing a model that integrates key findings and

insights, this study advocates for a multifaceted approach that emphasizes policy coherence, technological innovation, capacity building, and inclusive growth. By aligning government initiatives with the broader objectives of the SDGs and leveraging India's agricultural potential, the envisioned model serves as a blueprint for fostering resilience, equity, and environmental stewardship within the agricultural landscape. Ultimately, achieving sustainable development in agriculture necessitates concerted efforts from stakeholders across sectors, guided by a shared commitment to harnessing the transformative power of agriculture for the betterment of society and the planet.

Agroecological techniques, like Natural Farming, provide an affordable and environmentally friendly substitute that can help achieve the Sustainable Development Goals (SDGs). Through the reduction of input costs, these techniques are essential in improving farmers' income and financial stability, which in turn helps to alleviate poverty, promote gender equality, and build sustainable patterns of production and consumption.

The benefit of natural farming extends to zero hunger and food security through greater yield, diverse cropping, and year-round access to a range of income-generating crops and nutritious supplies. Natural farming's ecological preservation and water conservation features significantly improve water availability and management while also lowering CO₂ emissions at different points throughout the agricultural value chain.

In addition to addressing land degradation, less reliance on chemical inputs in agriculture also helps avoid marine pollution and ocean acidification caused by land-based activities. In addition, the implementation of Natural Farming enhances the general health of farmers and consumers, which may help lower the prevalence of various diseases in society. All things considered, Natural Farming presents itself as an all-encompassing strategy that is consistent with sustainable ideals and has the potential to promote favorable results in several SDG areas. However, to achieve its aspirations for the future, India must make the shift from a predominantly rural, informal economy to a hub of modern manufacturing, services, and information. This would enable India to capitalize on the global trend towards sustainability and increased technological sophistication.

Conflict of Interest Statement

The authors declare that there are no conflicts of interest that could influence the research conducted or the interpretation of the results presented in this paper. A conflict of interest arises when there is a divergence between an individual's private interests and his or her professional obligations to the research and its publication. Such conflicts may compromise the objectivity and integrity of the research process.

In compliance with ethical standards, the authors provide the following information:

Financial interests: The authors have no financial interests or affiliations with any organization that may have a direct or indirect interest in the subject matter discussed in this paper.

Non-financial interests: The authors have no non-financial interests that may be relevant to the research, including personal relationships, academic competition, or any other biases.

Should any potential conflict of interest arise during the course of the research or publication process, the authors commit to promptly disclosing such conflicts to the relevant parties and taking appropriate actions to address them.

This Conflict of Interest statement is made in the interest of full transparency and to ensure the credibility and objectivity of the research findings presented in this paper.

Authors' Contributions

Bijin Philip: Investigation, formal analysis, writing – original draft data curation, software, validation, visualization, etc.

Suresh G: Conceptualization and Methodology

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