International Journal of Theoretical & Applied Sciences, 15(1): 60-68(2023)

ISSN No. (Print): 0975-1718
ISSN No. (Online): 2249-3247

Sustainable Growth and Bursting Diversity in Indian Agriculture: A Profound Analysis

Tarkeshwar[1] and Pradip Kumar Saini[2]*
[1]Department of Genetics and Plant Breeding,
Acharya Narendra Deva University of Agriculture and Technology, Ayodhya - 224 229 (U.P.), India.
[2]Department of Crop Physiology,
Acharya Narendra Deva University of Agriculture and Technology, Ayodhya - 224 229 (U.P.), India.

(Corresponding author: Pradip Kumar Saini)*
(Received 10 April 2023; Accepted 29 June 2023)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: In the vibrant land of India, a crescendo of progress and development has been witnessed, stirring aspirations to ascend among the ranks of developed nations. Yet, amidst this accelerated advancement, apprehensions arise concerning the essence and well-being of the nation's core. A captivating notion, "sustainable development", has surged in popularity, extolled by experts advocating its embrace. Amidst the rapid growth that touches myriad facets, agriculture remains the very bedrock of the Indian economy. Embarking on a scholarly journey, this treatise endeavors to unravel and probe the enigma of sustainable development entwined within the realms of Indian agriculture. It endeavors to juxtapose the archaic agricultural system with the prevailing one, traversing the ecological, economic, and social dimensions of sustainability. Aspirations soar to uncover enduring remedies, fostering the propagation and embrace of sustainable practices. Foremost among the challenges besieging developing countries like India is the conundrum of food consumption and the burgeoning populace, an enigma clamoring for resolution. The panacea to this lies in amplifying agricultural output, a daunting yet indispensable quest. Alas, the intensive agricultural practices borne of the green revolution have ushered remarkable gains in yield and production, exacting a steep toll on the delicate tapestry of our ecosystem. It is in this backdrop that a succinct genesis of the prevailing landscape of Indian agriculture is portrayed, followed by an astute critique of the concept, unfurling both impediments and avenues for holistic sustainability.

Keywords: Sustainable Development, Agricultural Sustainability, Ecological Sustainability, Social Sustainability.

I. INTRODUCTION

Enthroned as the paramount sector within the Indian economy, agriculture reigns supreme, nurturing the livelihoods of nearly half the nation's workforce. A stalwart contributor, it bestows an 18% share upon the country's Gross Domestic Product (GDP). Proudly donning the mantle of the largest producer, India flaunts its mastery in cultivating an array of essentials – pulses, rice, wheat, as well as an enchanting repertoire of spices and spice-infused wonders. With a diverse bounty to offer, India's agricultural landscape extends a myriad of options to explore, encompassing dairy, meat, poultry, fishery, and an abundant harvest of various food grains (Evenson *et al*., 1999). Embarking on a remarkable journey, India now stands tall as the world's second-largest cultivator of fruits and vegetables, a testament to its agricultural prowess. This flourishing industry emerges as a stalwart contributor to the nation's sustainable economic growth, sowing seeds of prosperity far and wide. A nation's capacity to nurture its agricultural expansion sustainably hinges upon the artful equilibrium of its precious natural resources (Morya *et al*., 2016).

In a nation like India, where a staggering two-thirds of the populace find solace in agriculture despite the unyielding march of urbanization, the fate of the country rests firmly in the hands of this ancient art. A precarious truth unfolds - should agriculture falter, dire consequences loom over the economy, casting a dark shadow upon GDP and employment, with poverty lurking ominously in its wake. The trajectory of agriculture's swift expansion hinges upon the triumvirate of cultivable area, cropping intensity, and productivity, with the grand design of enhancing the sector's prosperity (Dar *et al*., 2019). Amidst these components, productivity stands tall, eclipsing its counterparts, for India grapples with limited land resources, while urbanization and industrialization forge ahead, marking the sands of time.

Within the realm of bolstering productivity, two formidable strategies emerge, each holding the power to elevate output. The first entails a deft utilization of available resources, a masterful dance that amplifies

yields. The second, no less potent, involves the alteration of inputs, a key to unlocking enhanced output. A clash of principles arises when productivity and sustainability stand at the crossroads. The former path, deemed superior, paves the way for immediate gains, yet its triumphs bear an ephemeral nature, for the burgeoning population thrusts forth a formidable challenge. Thus, the second path beckons, offering itself as a viable option, albeit one laced with potential harm to both environment and the tenets of economic sustainability. Indeed, the conundrums entwined with the pursuit of sustainable agriculture demand meticulous contemplation and decisive action (Kushwaha, 2003).

In the 1980s, the idea of sustainable development first appeared. It sparked a paradigm change in development thinking and still controls the conversation about development on all fronts, from the local to the international. The World Commission for Environment and Development (The Brundtland Commission) defined sustainable development as "the ability to meet the demands of the present without compromising the ability of the future generation to meet their own requirements" in its 1987 report, "Our Common Future" (Mishra, 2005). Changes in total crop production and crop production stability were utilized as indicators for the economic sustainability study. Food security and employment in rural labor markets were employed as indicators for social sustainability research. The analysis' conclusions showed that all of the provinces had a propensity for unsustainable agricultural production. Overuse of inorganic fertilizer, pesticides, and groundwater for irrigation in Sindh and Punjab was to blame for this (Zulfiqar and Thapa 2017).

II. SUSTAINABLE AGRICULTURE DEVELOPMENT

A development that is sustainable is one that satisfies current requirements without endangering the capacity of future generations to satisfy their own needs. It includes these three crucial ideas:

-Traditionally production methods
-Modern agriculture system
-Sustainable agriculture system.
-Ahead we can compare across three, amplitudes.
-Ecological sustainability
-Economic sustainability
-Social sustainability

A. Ecological Sustainability

A fundamental tenet of sustainable development is achieving human development goals while preserving the capacity of natural systems to deliver the natural resources and ecosystem services that are essential to the economy and society. A society in which living conditions and resources are utilised to satisfy human needs without endangering the stability and integrity of the natural system is the intended state. Sustainable development was described as "development that meets the requirements of the present generation without compromising the ability of future generations to meet their own needs" in the Brundtland Report of 1987 (Clark *et al*., 2020; UNGA, 1987). As the concept of sustainable development evolved, its emphasis shifted to economic development, social development, and environmental protection for future generations (Bhattacharya, 2003). In the tapestry of time, certain age-old farm practices have etched their mark, though regrettably, their ecological sustainability wanes. Misusing nature's bounty, they erode soil fertility, instigate soil erosion, and contribute to the global climate's metamorphosis. Amidst this backdrop emerges a beacon of hope - organic farming, a non-traditional method of cultivating crops, rising to prominence in recent times. Endowed with a plethora of benefits, this eco-conscious approach exerts a positive influence on income generation, the environment, and heritage (Morshedi *et al*., 2015; Balkrishna *et al*., 2021b). Embodying the principles of sustainability and eco-friendliness, organic farming stands resolute in replenishing soil carbon and nutrients, sowing the seeds of elevated crop yields (Srivastava *et al*., 2018). It dons the mantle of an ecological guardian, fortifying and conserving the fragile balance of nature (Gills and Sharma, 2021). Yet, challenges encircle this virtuous endeavor, chief among them being the high production costs and labor charges that cast their shadows even upon modest crop production (Balkrishna *et al*., 2021a).

But sustainable agriculture has some major advantages over traditional practice.

Soil Fertility

Soil fertility refers to the ability of soil to sustain agricultural plant growth, i.e. to provide plant habitat and result in sustained and consistent yields of high quality. Fertile soil has the following properties: The absence of toxic substances which may inhibit plant growth.

Climate

Conventional agriculture contributes to the production of greenhouse gases in various ways by reducing the amount of carbon stored in the soil and vegetation, through the production of Methane in irrigated fields and the production of artificial fertilizers, etc. By adopting a sustainable agriculture system, one can easily overcome this problem.

Health & Pollution

Chemicals, pesticides, and fertilizers badly affect the local ecology as well as the population. Indiscriminate use of pesticides, improper storage, etc. may lead to health problems. Sustainable agriculture reduces the use of hazardous chemicals and control pests.

Biodiversity

Sustainable agriculture practices involve mixed cropping, thus increasing the diversity of crops produced and raising the diversity of insects and other animals and plants in and around the fields.

Land use Pattern

Over-exploitation of land causes erosion, landslides and flooding clogs irrigation channels and reduces the arability of the land. Sustainable agriculture avoids these problems by improving productivity, conserving the soil, etc.

Water

Irrigation is the biggest consumer of fresh water, and fertilizer and pesticides contaminate both surface and

groundwater. Sustainable agriculture increases the organic matter content of the topsoil, thus raising its ability to retain and store water that falls as rain.

B. Economic Sustainability

A sustainable economy is necessitated for a variety of reasons, ranging from high-minded environmentalism to corporate interest. Agriculture to be sustainable should be economically viable over the long term. Conventional agriculture involves more economic risk than sustainable agriculture in the long term. Sometimes governments are inclined to view export-oriented production systems as more important than supply domestic demands. This is not right. Focusing on exports alone involves hidden costs: in transport, assuring local food security, etc. Policies should treat domestic demand and in particular food security as equally important to the visible trade balance. The main source of employment for rural people is farming. Trends towards specialization and mechanization may increase narrowly measured "efficiency", but they reduce employment on the land. The welfare costs of unemployment must be taken into account when designing national agricultural support programs. Sustainable agriculture, with its emphasis on small-scale, labor-intensive activities, helps overcome these problems.

1. The sustainability of the world economy: Since the planet's natural resources are finite, relying on sustainable methods globally must end. Any commercial enterprise that wants to last the long haul needs to invest in new resources and develop new procedures.
2. The sustainability of human life: The Earth and humanity's ability to live on it are in grave peril due to climate change brought on by excessive usage of fossil fuels. Humans have the chance to protect the earth for future generations by making an effort to reduce energy usage and change how food is produced.
3. Unacknowledged discoveries: Innovation and discovery have historically come from the natural world. Therefore, the chance to discover novel substances and processes that can form the basis of new goods or other economic advantages is threatened by the ongoing destruction of the natural environment.

A comprehensive study, meticulously following the guidelines set forth by the Agriculture Skill Council of India (ASCI) and the National Skill Development Corporation (NSDC), delved into the realm of organic farming, exploring its impact on the input and income of small and marginal farmers in Assam, Bihar, Jharkhand, and West Bengal. The findings reverberate with promise, unveiling the fruits of labor borne by 96 farmers, earnestly trained by the revered scientists of the PORI (Project Organic Revolution India). Their knowledge and wisdom, in turn, kindled a wave of transformation, encompassing a staggering 8,413 farmers. Reaping the rewards of their endeavors, the study discloses the maximum profits garnered in this green crusade, a resplendent Rs. 35,300 for rice in Assam, followed by a bountiful Rs. 30,500 for paddy hybrid in Jharkhand, trailing closely by Bihar and West Bengal. The resounding conclusion rings loud and clear - the current training module stands as a beacon of support, empowering farmers to enrich their lifestyle through the virtuous practices of organic farming (Balkrishna *et al*., 2021a).

C. Social Sustainability

Social sustainability in farming techniques is related to the ideas of social acceptability and justice. Development cannot be sustainable unless it reduces poverty. The government must find ways to enable the rural poor to benefit from agricultural development. Social injustice is when some section of society is neglected from development opportunities. But having a robust system of social sustainability can bridge the gap between “haves” and have-nots”. Due to a lack of acceptance by the local society, many new technologies struggle to find use in the agriculture industry. Sustainable agricultural methods are beneficial since they are based on regional societal norms, traditions, and customs. The locals are more likely to welcome and adopt them because they are familiar with them.

Furthermore, traditional expertise and regional creativity form the foundation of sustainable agricultural techniques. Locals are familiar with the crops and animals in their area. Traditional agriculture is more gendered, with women doing the bulk of the labor load. Sustainable farming guarantees that the costs and rewards are distributed equally among men and women. Sustainable agriculture increases food security by increasing the quality and nutritional worth of food, as well as by generating a wider variety of goods through time, whereas conventional farming concentrates on a small number of commodities. Caste and wealth-focused people were also the driving forces behind traditional farming. While the poor and lower castes were excluded, the wealthier and upper castes benefited more. Sustainable agriculture makes an effort to provide fair participation that acknowledges each person's voice and speech (Anonymous, 2008).

Technology, as a potent force, harnesses resources to create other valuable resources, permeating and being influenced by society's fabric, thereby shaping the holistic development of the community. Nevertheless, the allocation of resources to technological advancements necessitates a careful evaluation of how these innovations contribute to the overarching development goals. In the domain of agriculture and allied sectors, socioeconomic studies have primarily focused on economic impact indicators, such as gross income and net income, while often neglecting social impact indicators encompassing education, recreation, food security, social networking, membership in social organizations, and gender equality (Khan *et al*., 2022).

Unraveling the intricate ties between agricultural technology and its intended benefits for farmers proves to be a labyrinthine task (Mendola, 2007). The efficiency and effectiveness of these technologies are deeply entwined with the asset base of beneficiaries, spanning human capital, social capital, and environmental assets (Temple *et al*., 2018). Human capital encompasses a diverse range of attributes, including knowledge, skills, and labor power (Adato and Dick, 2002; Sima *et al*.,

2020). Social capital, on the other hand, involves critical elements like information exchange, savings and lending mechanisms, financial institutions, affiliations with diverse social networks and groups, a sense of solidarity and belonging, and resilience within the social-ecological fabric (Claridge, 2020). Lastly, environmental assets encompass invaluable resources like subsoil assets, land, forests, and water. Each of these components plays an indispensable role in shaping the intricate tapestry of agricultural technology's impact and its implications on the farmers' well-being.

India's journey has been nothing short of a breathtaking transformation, beginning with the trailblazing green revolution and transcending into the epochs of industrialization, liberalization, and globalization. Now, a new chapter dawns as the nation embarks on a path of smart development, propelled by innovation and sustainability. Yet, as progress takes center stage, the integration of society's needs becomes paramount. The multifaceted demands of a growing populace require land for cropping, forest conservation, recreation, transportation, and wildlife preservation. Alas, the availability of this precious resource diminishes with each passing day (Singh and Rajeev, 2017).

In this delicate balance between development and preservation, the nation faces a momentous challenge. It is a call to action, one that demands a conscientious approach to land utilization, where ecological integrity and human progress intertwine harmoniously. Striking this equilibrium holds the key to a future where India thrives as a beacon of responsible development, fostering prosperity for generations to come.

III. STATUS OF THE INDIAN AGRICULTURE SECTOR

Agriculture stands as one of the most pivotal pillars of the Indian economy, holding profound significance for over two-thirds of the nation's workforce dwelling in rural landscapes, serving as their primary source of livelihood. Remarkably, 65% of India's labor force finds solace in the embrace of agriculture, which, in turn, contributes a substantial 27% to the country's GDP, fuels 21% of all exports, and serves as a vital source of raw materials for various industries. Within this vibrant tapestry, the cattle sector commands a significant role, bestowing approximately 8.4% of the nation's GDP and a remarkable 35.85% of agricultural output. The heart of India's rural existence pulsates, with nearly 75% of the population, cultivating the land and residing in rural realms that encompass 43% of the country's vast expanse. Amidst this fertile terrain, an impressive estimate of 211.17 metric tonnes of food grain blooms forth, a testament to the nation's agricultural prowess. The vast canvas of agriculture sprawls across 329 million hectares, where 265 million hectares mirror varying levels of potential productivity. Of this grand expanse, 143 million hectares stand as the net sown area, graced by 56 million hectares of net irrigated lands, fostering growth and sustenance.

In the vast expanse of India, a panorama of diverse vegetation, geology, temperatures, and landforms unfolds, underscoring the regional diversity that both enriches and shapes the nation's unequal economic and agricultural progress.

According to the Land Use Statistics of 2016-17, India's vast topographical expanse encompasses a reported net sown area of 328.7 million hectares and a net irrigated land of 139.4 million hectares. The country's gross cropped area stands at 200.2 million hectares, boasting an impressive cropping intensity of 143.6%. In the grand tapestry of the overall geographical area, 42.4% is dedicated to sown net area, while the net irrigated land spans across 68.6 million hectares (Anonymous, 2021).

The agriculture and allied sector play a momentous role in India's economic ecosystem, engaging a remarkable 54.6% of the country's entire workforce and contributing 17.8% to India's Gross Value Added (GVA) in 2019-20 (Anonymous, 2021). Recognizing the paramount importance of the agricultural sector, the Government of India has embarked on numerous initiatives to foster its sustainable growth.

Given India's status as the second most populous country in the world, with over 50% of its population engaged in agricultural practices, agricultural mechanization emerges as a vital pursuit. Leveraging farm equipment, implements, and power sources, this process aims to reduce reliance on draft animals and human labor while enhancing cropping intensity, precision, and timeliness of crop input utilization, while also minimizing damages throughout various stages of crop production (Balkrishna *et al*., 2021c). The availability of farm power has witnessed remarkable growth, projected to reach 4.0 kW/ha in 2022 from a mere 0.25 kW/ha in 1951. This transformation is mirrored in crop production, which has surged to a record 784.63 million tonnes in 2020-21 from 170.21 million tonnes in 1950-51. In sync with this progress, tractor and power miller sales have witnessed substantial growth, increasing by 3.65 and 2.17 times, respectively, in 2019-20 compared to 2004-05.

Table 1: Ranking of India in various agricultural sectors in the world.

S. No.	Production various areas	Ranks
1.	Milk	1st
2.	Irrigated Area	1st
3.	Livestock (Buffaloes, Castles)	1st
4.	Population	2nd
5.	Production	**2nd**
6.	Wheat production	**2nd**
7.	Production of Inland Fish	**2nd**
8.	Economically active population	**2nd**
9.	Economically active population	**2nd**
10.	Total Cereals	**3rd**
11.	Fish	**7th**
12.	Area	**7th**

However, amidst this advancement, there remains a pressing need to enhance knowledge of cultivars and establish Farm Machinery Training & Testing Institutes and Custom Hiring Service Centres (CHC) in remote areas (Balkrishna *et al*., 2021c).

IV. AGRICULTURAL PRODUCTION IN INDIA

The majority of India's agricultural output is directly correlated with the best possible exploitation of the nation's natural and human resources. As a result, riding on favorable agro-climatic conditions and a wealth of natural resources, India has emerged as the world's top producer of a number of commodities. The nation is a major producer of black pepper, ginger, turmeric, cashew nuts, coconuts, mangoes, milk, bananas, dairy products, and pulses. Furthermore, it ranks second in terms of the production of fruits, vegetables, cotton, sugar, wheat, rice, and sugar. Using adequate and efficient water management techniques would significantly increase Indian agriculture production (GOI, 2007). The majority of India's agricultural activities are restricted to a few monsoon months. India often receives abundant rainfall during the monsoon season; yet, sometimes, this bountiful monsoon transforms into horror, creating uncontrollable floods in many sections of the nation and ultimately harming farm production (Gulati *et al*., 2005).

Table 2: Contribution of agriculture and allied sectors towards GDP in recent years in India

S.N.	Year	% Contribution towards GDP
1.	2018-19	17.6
2.	2019-20	18.4
3.	2020-21	20.3
4.	2021-22	19.0
5.	2022-23	18.3

Source: National Statistical Office (NSO), M/o Statistics & PI.

V. EMPLOYMENT GENERATION CAPACITY OF INDIAN AGRICULTURE

Intriguingly, India's urban landscape underwent a significant metamorphosis between 2010 and today, as reported by the United Nations Development Programme (UNDP). Back in 2010, the urban population accounted for a mere 30%, but brace yourself, for it is projected to soar to 40% in the year 2030 and a mind-boggling 50% by the year 2045. The magnitude of this transformation is awe-inspiring. But hold your breath for an even more astonishing revelation! India's urban expansion, propelling relentlessly forward, is anticipated to catapult its urban population from a current 3.5 billion to an astounding 6 billion by the year 2050 (Balkrishna *et al*., 2021d). This surge in urban inhabitants is unprecedented in history and is poised to redefine the nation's trajectory in ways unfathomable. As if unfolding a perplexing enigma, the areas under cultivation, in sharp contrast, experience a relatively modest growth rate of a mere 2% each year, as attested by Agarwal & Sinha in 2017. It's as if nature herself hesitates to compete with the rapid urban sprawl that engulfs the landscape.

To grasp the magnitude of this urban evolution, we must unravel the intricacies beneath its surface, where exponential growth intertwines with a dynamic landscape. India's future unfolds with a burst of complexity, painting a portrait of progress that leaves us in awe of the forces shaping our civilization.

During the period of 2019-20, the Indian economy witnessed a consistent growth in employment generation across various sectors, even amidst the challenges posed by the first wave of Covid-19 in April-June 2020. The industry sector added 3.4 million jobs, while the services sector contributed 6 million jobs during this timeframe. Notably, the agriculture and allied sector emerged as a significant source of employment, providing opportunities to 40% of male workers, 60% of female workers, and 45.6% of the overall workforce in 2019-20. Breaking down the employment distribution, the industry sector absorbed 26% of male workers and 16.6% of the total female workforce. Meanwhile, the service sector employed 33.6% of male workers and 23.5% of female workers. A remarkable observation emerges from these statistics, revealing that a substantial 60% of all female workers in the country found employment in the agriculture sector, with 17% in the industry sector and 23% in services. In contrast, for male workers, 40% were employed in agriculture, 27% in industry, and one-third in the services sector (NITI Ayog, 2022). This data underscores the significant role played by the agriculture sector in generating employment opportunities, particularly for female workers, making it a pivotal contributor to the nation's labor force.

Table 3: Number of workers (male and female) employed in agriculture, industry and services during Periodic Labour Force Survey (PLFS) years, million.

Year	Rural			Urban			Rural + Urban		
	Agri.	Industry	Service	Agri.	Industry	Service	Agri.	Industry	Service
2017-18	193.2	67.7	64.4	8.0	45.4	77.2	201.2	113.0	141.5
2018-19	191.3	70.9	68.5	7.6	46.8	83.1	199.0	117.8	151.6
2019-20	224.8	73.1	67.5	8.4	48.0	90.0	233.2	121.2	157.5

Source: Authors estimates based on NSO-PLFS data and population data

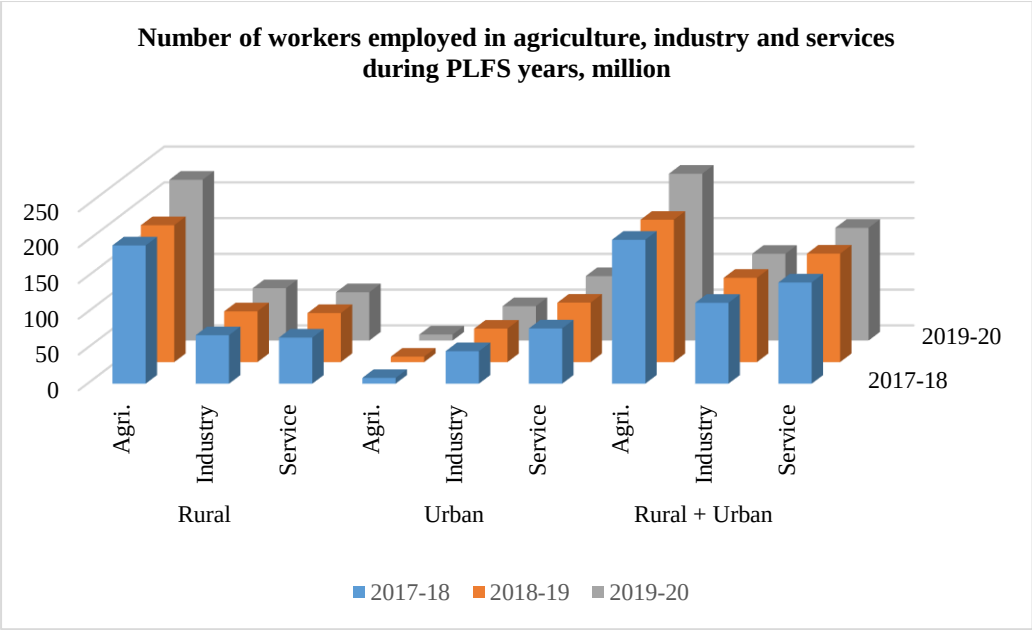

Fig. 1. Employment generation through agriculture, industry and service.

VI. REVOLUTIONS IN INDIAN AGRICULTURE

A. Green Revolution

The Intensive Agriculture District Program (IADP), which eventually gave rise to the Green Movement, is one component of this revolution. It was decided to create the National Bank for Agriculture and Rural Development (NABARD). The focus was on high-yielding cultivars as well as other contemporary inputs like chemicals, fertilizers, pesticides, and mechanization. It was focused on how agriculture productivity could be increased without having a significant impact on the expanding area under cultivation.

B. White and Yellow Revolution

The Green Revolution created a sense of assurance in our abilities to advance agriculture, which paved the way for the subsequent phase, which is represented by the Technology Mission. The emphasis under this strategy was on commerce, consumption, and conservation. Progress was steady and occasionally remarkable, particularly in the case of milk and egg production, as a result of the introduction of an end-to-end strategy that focused on all links in the production-consumption cycle.

C. Ever Green Revolution

Prof. M.S. Swaminathan, the man credited with starting India's Green Revolution, declares to be pro-woman, pro-nature, and pro-poor. The key to the ever-green revolution is the preservation of biodiversity, upkeep of soil fertility, and improvement of food crop climate resilience in combination with greater and more widespread education and technical innovation. This revolution's main goal is to increase production while using less water, land, and fertilizer. In order to attain global food security, a new collaboration in the agriculture sector was established with India during the recent visit of the US President to New Delhi in March 2010.

D. Blue Revolution (Water, Fish)

It has been influenced in part by a movement toward healthier eating that has seen an increase in fish consumption. The availability of wild fish is also dwindling. Women and landless workers may have excellent employment opportunities as a result of this revolution, which would empower them.

E. Bio-Technology Revolution

India is in a good position to become a major player in the global biotech market. By 2010, India could lead the world in the production of various additional genetically modified vegetables and transgenic crops due to the enormous development potential of the sector. India has had a startling 30% growth over the past five years in the agri-biotech sector. The Indian economy's primary driver, the food processing industry, is currently expanding at a 13.5% rate.

Table 4: Some revolutions in related agriculture.

Sr. No.	Revolution	Related with the production of
1	**Vertical revolution in Agriculture**	Maximizing production /land area, cropping etc.
2	**Brown revolution**	Food processing
3	**Grey revolution**	Fertilizer production
4	**Yellow revolution**	Oil seed production (Mustard)
5	**Silver revolution**	Egg /poultry production
6	**Food Chain revolution**	Food grain production

VII. FACTS OF ECONOMIC REFORM IN INDIAN AGRICULTURE

Since the 1990s, the Indian agriculture sector has undergone significant economic reform, driven by the objective of liberalizing the economy and harnessing the potential of globalization. Prior to the early 1990s, India, despite being one of the largest economies reliant on agriculture, operated under a closed economic system. However, in 1991, a wave of new economic policies swept through the nation, placing equal emphasis on internal and external reforms. These reforms encompassed various domains, such as industrial policies, price and distribution controls, fiscal restructuring in the financial and public sectors, as well as changes to the exchange rate, trade, and foreign investment policies in the external sector.

The journey of economic reform in India began in June 1991, with the anticipation of a surge in exports following liberalization. However, it was observed that the expected increase in exports did not materialize. Moreover, from 1992-1993 to 1998-1999, the output growth of the agricultural sector experienced a decline. This downturn can be attributed to a deterioration in the environmental quality of the land, which adversely impacted the marginal productivity of modern inputs (Gulati, 2009).

The significance of the agriculture sector in India goes beyond its economic implications; it lies at the very heart of the nation's socio-economic fabric. Any alterations to the structure of this sector are likely to reverberate across the country's existing pattern of social equality. It is imperative to recognize that sustained and widespread agricultural development is indispensable for uplifting living conditions, alleviating poverty, ensuring food security, and propelling national economic growth to new heights. Without such agricultural advancement, no economic reform approach can truly thrive and succeed (Mishra and Rao, 2003).

Since agriculture continues to be a tradable sector, this economic liberalization and reform policy has a far-reaching effect on

-Food security
-Agricultural price
-A pattern of agricultural growth
-Investment in new technologies
-Agricultural income and employment

Agricultural exports and imports Reduction in Commercial Bank credit to agriculture, instead of this reforms process and recommendations of Khusro Committee and Narasimham Committee resulted in a fall in farm investment and impaired growth. Liberalization of agriculture and open market operations enhance competition in “resource use” and “marketing of agriculture production”, which forces the small and marginal farmers to resort to “distress sale” and seek off-farm employment for supplement income.

VIII. ISSUES AND CHALLENGES

The pivotal challenge in agricultural development lies in the imperative to boost production, create employment opportunities, and provide a sustainable source of income for the underprivileged segments of the population. According to studies conducted by the Food and Agriculture Organization (FAO), small farms in developing nations contribute a significant 30-35 percent of the overall agricultural output. However, India's adoption of modern technologies has been gradual, and its farming practices tend to be haphazard and unscientific (Braun *et al*., 2005).

To foster the growth of the Indian agriculture industry, there are several fundamental concerns that require attention. The revival of cooperative institutions stands as a crucial step towards empowering farmers and facilitating collective progress. Strengthening rural finance mechanisms ensures that adequate financial support reaches those engaged in agriculture, propelling their ventures forward. Research and human resource development play instrumental roles in equipping farmers with updated knowledge and skills, enhancing productivity and efficiency. Prioritizing trade and export promotion opens up new avenues for farmers to access broader markets and tap into the global demand for agricultural products. Land reforms are essential in ensuring equitable land distribution and securing farmers' land rights, a cornerstone of agricultural development. Lastly, investing in education creates a knowledgeable and empowered workforce, capable of driving agricultural growth and contributing to the nation's prosperity. Addressing these fundamental concerns is crucial to nurturing the development of the Indian agriculture industry, paving the way for increased production, enhanced livelihoods, and inclusive economic growth.

At the local, national, and global echelons, the looming specter of climate change casts a formidable shadow over agricultural production. This somber reality manifests itself through declining agricultural yields, besieged by the relentless assault of abiotic and biotic stresses. To address these pressing challenges and safeguard food security for an ever-expanding populace, the adoption of sustainable and innovative agricultural practices becomes not just an option but an imperative. In this turbulent landscape, where traditional approaches falter, the emergence of sustainable and innovative agricultural practices presents a glimmer of hope. Embracing smart farming technologies, nitrogen fixing cereals, and genetically modified crops offers a potential lifeline. These interventions promise to revitalize agriculture and fortify it against the destabilizing forces of climate change. Furthermore, holistic approaches such as improved residue management, conservation agriculture, and cover crops for enhancing soil health find their place in this transformative journey. The strategic application of nanofertilizers, ushering in increased nutrient use efficiency, and the adoption of bioplastic mulches contribute to the arsenal of climate-resilient agricultural practices (Shekhar *et al*., 2022).

Agricultural ingenuity extends to the granular level as well, with interventions like the urea briquette applicator in rice and the application of silicon in crops, each playing their part in bolstering resilience. Moreover, innovations

like speed breeding and laser land leveling, epitomizing human adaptability, chart a course towards a sustainable agricultural future. In the face of climate change's relentless onslaught, it is through the confluence of these sustainable and innovative practices that agriculture finds strength. By embracing change and adapting our agri-food systems, we embark on a transformative journey to secure the sustenance of generations to come. Together, we confront the formidable challenges ahead and cultivate a future where agriculture stands tall in the face of adversity.

IX. PROSPECTS AND SOLUTIONS FOR INDIA'S FUTURE

Any alteration in the structure of the agriculture sector, which stands as a significant contributor to the Indian economy and a pivot around which socioeconomic privileges and disparities revolve, is bound to reverberate through the current social equity pattern. The key to sustainable agricultural output lies in the effective and prudent utilization of vital resources such as soil, water, livestock, plant genetics, forests, climate, rainfall, and topography. However, Indian agriculture faces a myriad of challenges stemming from resource limitations, infrastructure constraints, institutional barriers, technical limitations, and policy-induced restrictions.

For the fulfillment of human needs in both the present and future generations, sustainable development entails the prudent management and preservation of the natural resource base, alongside the deliberate orientation of technical and institutional changes (Dev, 2008). True sustainable development in the agriculture, forestry, and fisheries sector is characterized by environmental preservation, technical suitability, economic feasibility, and social acceptance. It seeks to safeguard and conserve precious resources, including land, water, plant, and animal genetic resources. To achieve sustainable agricultural development, it becomes crucial to optimize the utilization of natural resources, human resources, financial resources, and technical expertise.

The slowdown in the growth rate of the agriculture sector in India is largely attributed to the heavy dependence on rainfall for crop yields (Rao, 2003). This vulnerability disproportionately affects small farmers and workers who reside on the margins, making them most susceptible to uncertainties. In light of these challenges, it is imperative to provide support and assistance to farmers, ensuring they have access to adequate water and energy resources. This will help safeguard them from the perils posed by fires, floods, and droughts, empowering them to thrive and contribute to the sustainable growth of the agriculture sector.

India should understand that, as the second most populous nation in the globe, it is a valuable resource for the entire continent. There are a lot of idle people in India. It's important to figure out how to tap into their expertise and get more people involved in the progress. Passive unemployment is noticeable, particularly in agriculture. The full use of human resources can also help India achieve sustainable growth. Since a major portion of the country's poor population works in agriculture, raising their living standards is essential to the nation's overall development (Kumar and Mittal, 2006). This gap between the classes will only widen if we continue to ignore the poor. Farmers across the nation are being driven to suicide by debt traps. The population of slums in cities is growing as more people move to the city in search of greater economic opportunities. Therefore, it is necessary to provide rural residents with employment opportunities and a chance to develop. India has been classified as a "developing" nation for a considerable amount of time; in order to move toward "developed" nations, we must reduce our extreme reliance on the agricultural sector.

X. CONCLUSION

The journey of agricultural development in India has been marked by both progress and challenges. While the sector has undergone economic reforms and witnessed advancements in certain areas, there remain pressing concerns, particularly regarding the adoption of modern technologies and the need for sustainable practices. The pivotal role of agriculture in the Indian economy cannot be understated, with its impact reverberating through social equity patterns and the livelihoods of millions. To ensure a prosperous and sustainable future for Indian agriculture, it is crucial to address resource limitations, infrastructure constraints, and policy-induced restrictions, while embracing practices that prioritize profitability and ecological sustainability. By empowering small-farm management and fostering an environment conducive to sustainable agriculture, India can chart a course towards holistic and enduring agricultural development. The challenges may be formidable, but with collective efforts from farmers, policymakers, researchers, and stakeholders, the potential for a thriving and sustainable agricultural sector shines brightly on the horizon.

In conclusion, adopting small-farm management strategies that elevate the productivity, profitability, and sustainability of the farming system holds the key to ensuring comprehensive sustainability in the agricultural domain. By prioritizing sustainable practices, we can pave the way for a brighter, more resilient future for agriculture and the environment alike.

Acknowledgments. The authors are thankful to the Vice Chancellor of the Acharya Narendra Deva University of Agriculture and Technology, Ayodhya to facilitate the university for better place of study as well as to motivate us for always being energetic and continuous in our works.

Conflict of Interest. There is no conflicts of interest among authors regarding this study.

REFERENCES

Adato, M. & Dick, M. R. (2002). Assessing the impact of agricultural research on poverty using the sustainable livelihoods framework. Environment and production technology division discussion paper no. 89. Washington, DC: International Food Policy Research Institute.

Agarwal, H. P. and Sinha, R. (2017). Urban Farming - A Sustainable Model for Indian Cities. *International Journal on Emerging Technologies*, *8*(1), 236-242.

Anonymous (2008). Productivity and Sustainability in Agriculture: An Application of LPP Model. *International Journal of Management Research and Technology*, *2*(2), July-Dec 2008.

Anonymous (2021). Annual Report 2020-21 - Department of agriculture, cooperation & farmers' welfare. Ministry of Agriculture & Farmers' Welfare, Government of India Krishi Bhawan, New Delhi. Retrieved from https://agricoop.nic.in/sites/default/files/Web%20copy%20of%20AR%20%28Eng%29_3.pdf

Balkrishna, A., Kumar, P., Joshi, R., Kumar, A., Sharma, G., Dhyani, A. and Arya, V. (2021a). Effect of Organic Farming on Input and Income in Eastern States of India. *Biological Forum – An International Journal*, *13*(3), 392-397.

Balkrishna, A., Chaudhary, P., Joshi, R., and Arya, V. (2021b). Organic Farming: A Promising Approach for Sustainable Agriculture. Sustainable Agriculture for Food Security: A Global Perspective. *CRC Press*, 151.

Balkrishna, A., Sakshi, Arya, V., Sharma, N. and Sharma, G. (2021c). Unveiling Role of Agricultural Mechanization in Improving Production and Yield. *Biological Forum – An International Journal*, *13*(3), 438-443.

Balkrishna, A., Phour, M., Thapliyal, M. and Arya, V. (2021d). Current Status of Indian Agriculture: Problems, Challenges and Solution. *Biological Forum – An International Journal*, *13*(3), 361-374.

Bhattacharya, B. B. (2003). Trade Liberalization and Agricultural Price Policy in India since Reforms, *India Journal of Agricultural Economics*, *58*(3).

Braun, J. V., Gulati, A., Hazell, P., Mark W. Rosegrant and Ruel, M. (2005). Indian Agriculture and Rural Development- Strategic Issues and Reform Options.

Claridge, T. (2020). Social capital & poverty alleviation. Social Capital Research, 1-2.

Clark, W. and Harley, A. (2020). Sustainability Science: Toward a Synthesis. *Annual Review of Environment and Resources*. *45*(1), 331–86. doi:10.1146/annual-environ-012420-043621.

Dar, A. A., Rather, M. Y., Yaseen, J. M. W., Wani, K. A. and Vasu, D. (2019). Biochar: Preparation, Properties, and Applications in Sustainable Agriculture. *International Journal of Theoretical & Applied Sciences, 11*(2), 29-40.

Dev, S. M. (2008). Inclusive Growth in India, Agriculture, Poverty and Human Development, Oxford University Press, New Delhi.

Evenson, R. E., Pray, C. and Rosegrant, M. W. (1999). Agricultural Research and Productivity Growth in India. Research Report No 109. International Food Policy Research Institute, Washington, D.C.

Gills, R. and Sharma, J. P. (2021). From an Empty-Plate Lunch to Silk-Stocking Dinner: Some futuristic Approaches in Agriculture. In Climate Change and Resilient Food Systems Springer, 35-72.

GOI (2007). Report of the Steering Committee on Agriculture for 11th Five Year Plan, Yojana Bhavan, New Delhi.

Gulati, A. (2009). Emerging Trends in Indian Agriculture: What can we learn from these? Prof. Dayanath Jha Memorial Lecture, National Centre for Agricultural Economics and Policy Research, New Delhi.

Gulati, A., Meinzen-Dick., Ruth, and Raju, K.V. (2005). Institutional Reforms in India Irrigation, Sage Publication.

Khan, G. A., Rashid, H., Ahmad, M.N. & Chowdhury, S. R. (2020). Post-adoption analysis of sericulture technologies: Need of the hour. *Indian Silk*. 11 old *59* (3), 22-23.

Kumar, P. and Mittal, S. (2006). Agricultural Productivity Trends in India: Sustainability Issues. *Agricultural Economic Research Review*, *19*, 71-88.

Kushwaha, N. (2003). Environment, Sustainable Development and Rural Poverty in India. Ph.D. Thesis, M.J.P. Rohilkhand University, Bareilly Ch. 4.

Mendola, M. (2007). Agricultural technology adoption and poverty reduction: A propensity score matching analysis for rural Bangladesh. *Food Policy*, *32*(3), 372-393.

Mishra, N. (2005). Eco-feminism: A global concern, Social welfare, 3–8.

Mishra, V. N. and Rao., G. (2003). Trade Policy, Agricultural Growth and Rural Poor: Indian Experience 1978-79 to 1999-00. *Economic and Political Weekly*, October 25, 2003.

Morshedi, L., Lashgarara, F., Hosseini, S. J. F. and Najafabadi, M. O. (2015). The Role of organic farming in improving food security in Fars Province. *Biological Forum-An International Journal*, *7*(2), 426-429.

Morya, G. P., Kumar, K., and Yogesh (2016). Revival of ITK for Sustainable Agriculture under Eastern Uttar Pradesh (India). *International Journal of Theoretical & Applied Sciences, 8*(2), 40-44.

NITI Ayog (2022). Workforce Changes and Employment: Some Findings from PLFS Data Series. *NITI Aayog Discussion Paper 1/2022*, pp. 8-9.

Rao, Hanumantha. (2003). Reform Agenda for Agriculture. *Economic and Political Weekly*, Feb 15, 2003.

Sekhar, G., Naveen, J., Thokchom, S., Bharteey, P.K., Yadav, R., Sarvajeet and Kumar, R. (2022). Novel and Sustainable Approaches to Combat Climate Change in the Agriculture Sector: A Review. *Biological Forum – An International Journal*, *14*(4), 203-210.

Sima, V., Gheorghe, I. G., Subi, J. & Nancu, D. (2020). Influences of the Industry 4.0 Revolution on the Human Capital Development and Consumer Behavior: A Systematic Review. *Sustainability*, *12*(4035), 1-28.

Singh, P. and Rajeev, R. (2017). Clusterization as a Tool for Sustainable Development. *International Journal on Emerging Technologies*, *8*(1), 272-278.

Srivastava, P., Singh, R., Tripathi, S., Singh, H., Raghubanshi, A., S. & Mishra, P. K. (2018). A new insight into the warming potential of organically amended agro-ecosystems. *Organic Agriculture*, *8*(4), 275-284.

Temple, L., Barret, D., Blundo Canto, G., Dabat, M. H., Devaux-Spatarakis, A., Faure, G. & Triomphe, B. (2018). Assessing impacts of agricultural research for development: A systemic model focusing on outcomes. *Research Evaluation*, *27*(2), 157-170.

United Nations General Assembly (1987). Report of the World Commission on Environment and Development: Our Common Future. Transmitted to the General Assembly as an Annex to document A/42/427 – Development and International Co-operation: Environment.

Zulfikar, F. and Thapa, G. B. (2015). Agricultural Sustainability Assessment at Provincial Level in Pakistan Land use policy, *68*, 492–502.