PROPELLING TOWARDS SUSTAINABLE AGRICULTURE IN INDIA: STAKEHOLDERS' PERSPECTIVES IN THE STATES OF PUNJAB, HARYANA, AND UTTAR PRADESH

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I. INTRODUCTION

In order to transform rural economies, rural diversification is essential. This is achieved through the introduction of new business ventures and the expansion of existing ones into new markets. This process increases economic activity, creates jobs, and strengthens and balances the economy. Although they are constantly evolving, traditional sectors like agriculture and forestry are still essential. Examples of agricultural diversification include the adoption of alternative crops, the introduction of new livestock breeds, and organic farming. Creating a variety of jobs and income sources for the rural economy is another aspect of diversification that extends beyond agriculture. The structure of rural labour markets, which leads to major changes in these markets, has a major impact on the speed and nature of this diversification.[1] The structure of rural labour markets, which leads to major changes in these markets, has a major impact on the pace and nature of this diversification. Family dynamics also exhibit diversification, with members of the household working multiple jobs as a result of the division of labour by gender and age. Households that rely solely on agriculture are giving way to more complex labour market interactions. Agriculture has long dominated India's rural landscape, contributing nearly 50% of the nation's GDP in the early 1970s. By 2019–20, this percentage had dropped to roughly 18%, but over 50% of the workforce was still employed. Such discrepancy increases the burden on agriculture and reduces labour productivity when compared to non-agricultural work in rural areas. Resolving these problems through effective rural diversification strategies is therefore essential to sustainable rural development.[2]

Agriculture remains the backbone of India's economy, engaging more than half the workforce. However, while it provides food security and rural employment, it faces complex challenges including climate change, declining land productivity, and groundwater depletion. The legal and justice-related dimensions of agriculture—farmers' rights, entitlements, and equitable access to state schemes—are often underexplored. This paper examines agriculture through a socio-legal perspective, situating government policies within the framework of rights, justice, and sustainable development. It particularly focuses on Punjab, Haryana, and Uttar Pradesh, regions critical to India's Green Revolution, while also employing an

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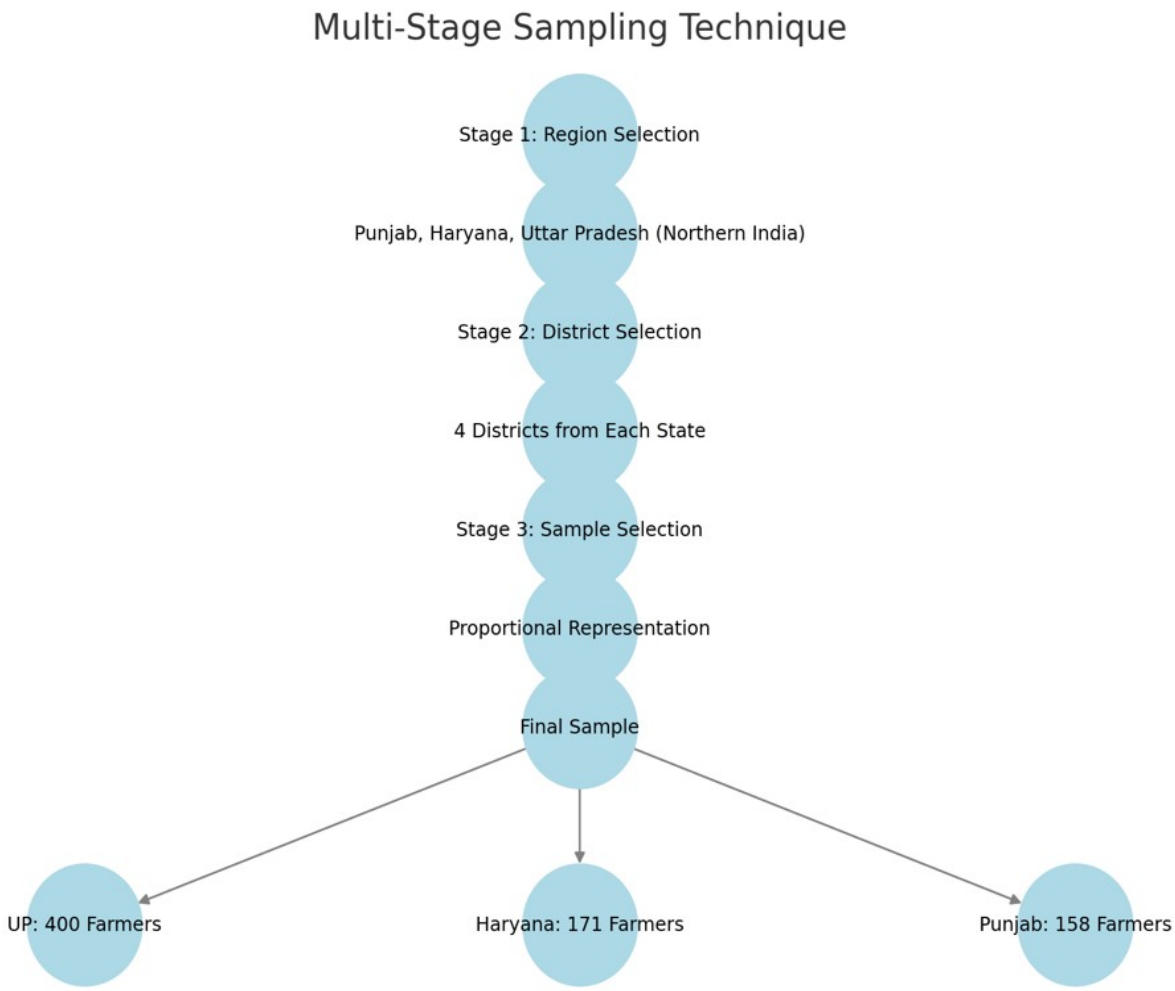
[1] Ramesh Chand and S.K. Srivastava, "Changes in the Rural Labour Market and their Implications for Agriculture" 10 *Economic and Political Weekly* 47, 49 (2014).
[2] Press Information Bureau, "Contribution of Agriculture Sector towards GDP", *available at*: https://pib.gov.in/PressReleasePage.aspx?PRID=1741942 (last visited Jan. 04, 2025).

empirical approach grounded in farmers' perspectives. The central research problem lies in understanding whether agricultural policies in Northern India adequately address farmers' rights and ensure equitable access to entitlements. The objectives are: (a) to examine the socio-legal dimensions of agricultural sustainability; (b) to assess farmers' awareness of legal entitlements and schemes; and (c) to provide recommendations for policy and judicial interventions. The three states- Punjab, Uttar Pradesh, and Haryana those were particularly important to India's Green Revolution. The article intends to assess the effectiveness of agricultural policy and identify any areas needing intervention via legislative amendments by means of an empirical analysis of these states. Focusing on the issue of sustainability, the article looks at how present farming practices affect the environment. Combining information from numerous sources aims to also solve socioeconomic inequities in the agricultural sector and provide analytical analysis to stakeholders, researchers, and lawmakers, thereby enhancing agricultural sustainability. The study employs a multi-stage sampling method, covering 729 farmers across Punjab, Haryana, and Uttar Pradesh. It combines structured surveys, in-depth interviews, and secondary data analysis. Quantitative and qualitative methods are used to capture both statistical patterns and stakeholder narratives. The research adopts a socio-legal framework to interpret how law, policy, and governance interact with agricultural realities.



II. AGRICULTURAL ECONOMY

A. Internal Contribution

In some of the least developed countries, where it can account for more than 25% of the GDP, agriculture accounts for 4% of the global GDP, making it a vital sector for economic growth[3]. Agriculture may help battle poverty, raise income, and improve food security for the 80% of the world's poor who live in rural regions and mostly work in agriculture.[4] In India, a major section of the population is engaged in agriculture. They practise diverse forms of work associated with this field. The conventionally attributed tasks to agriculture included cultivating the land, but with the passage of time, there seems to have been a widening chimera of an all-inclusive economic model for this sector. The traditional (agricultural or informal) components of the Indian economy are being structurally replaced by the modern (industrial or official) sectors. Compared to output, this transition in labour employment has been rather modest. However, in recent times, the labour market has also begun to catch up with the shifts in the output sectoral composition[5]. Over the past two years, the agricultural sector in India has seen a significant increase in growth, with a rise of 3.6% in 2020-21 and 3.9% in 2021-22. This has resulted in a sizable contribution of 18.8% (2021-22) to the country's Gross Value Added (GVA), which indicates the strong economic implications of agricultural development in India[6]. The implementation of the Minimum Support Price (MSP) policy has encouraged crop diversification, which has further contributed to the growth of the agricultural sector. According to the most recent Situation Assessment Survey (SAS), net crop revenues have grown by 22.6% since the SAS Report in 2014, demonstrating a good trend in agricultural production and income for farmers.[7] Furthermore, allied industries including animal husbandry, fisheries, and dairying are gradually establishing themselves as high-growth markets and important contributors to the expansion of the agricultural sector as a whole.[8] These economic developments highlight the potential for continued growth and prosperity in the Indian agricultural sector, which can have positive ripple effects on the broader economy.

B. External Contribution

India is a leading agricultural exporter in the globe. The following data depicts exports over the last few years.

(i) Statistical figures from 2021-2022

The country's entire agricultural exports in 2021-22 was US$ 49.6 billion, up 20% from US$ 41.3 billion in 2020-21. India's agriculture industry's primary exports include

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[3] The World Bank, *Agriculture and Food* (*The World Bank*, 2024); *available at:* https://www.worldbank.org/en/topic/agriculture#:~:text=Agriculture%20can%20help%20reduce%20poverty,a%20leading%20financier%20of%20agriculture (last visited on Jan. 15, 2025).

[4] *Ibid.*

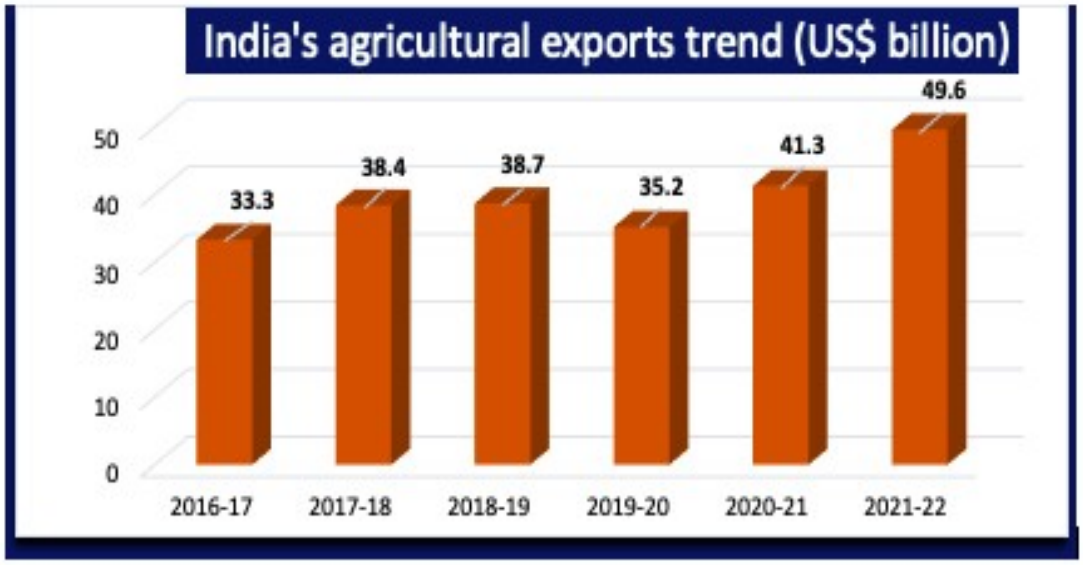
[5] Ramesh Chand and S.K. Srivastava "Changes in the Rural Labour Market and their Implications for Agriculture" 49(10) *Economic and Political Weekly* 47, 48 (2024).

[6] Ministry of Finance, "Key Highlights of the Economic Survey 2021-22" (Press Information Bureau, Jan. 31, 2022), *available at:* https://pib.gov.in/PressReleasePage.aspx?PRID=1793829#:~:text=The%20highlights%20of% 20the%20Economic,real%20terms%20in%202022%2D23 (last visited on Nov. 12, 2024).

[7] Rai Vinaykumar, "Economic Survey: Average monthly income per agricultural household at Rs.10" *Business Today*, Jan. 31, 2022.

[8] *Ibid.*

agricultural and associated products, marine products, plantation products, and textile and allied items. Exports of agriculture and associated items were US$ 37.3 billion, up 17% from 2020 to 2021. [***see Figure 1:*** **India's Agriculture Exports Trends (US$billion)**]



Source: Ministry of Commerce & Industry

Figure 1. India's Agriculture Exports Trend (US$ Billion)

(ii) Statistical figures from 2022-2023

The country reached 58% of its total export target for 2022-2023 in the first half of the current fiscal year as a result of efforts implemented by the Ministry of Commerce and Industry through APEDA. For fiscal year 2022-2023, APEDA announced an export target for the "agricultural and processed food products basket" of USD 23.56 billion, with USD 13.77 billion already shipped during the first six months of the current fiscal year.[9]

[9] *Ibid.*

Figure 2. India's Export Comparative Statement: APEDA Products

Product Head	April-Sept, 2021	April-Sept, 2022	% Change (April-Sept, 2022)
	USD Million		
Fruits	301	313	4.04
Cereal Preparation & Miscellaneous Processed items	1632	2111	29.36
Meat, dairy & poultry products	1903	2099	10.29
Basmati Rice	1660	2280	37.36
Non-Basmati Rice	2969	3207	8.03
Other Products	2591	3761	45.16
Total	**11056**	**13771**	**24.55**

Source: DGCIS Principal commodities data April-September, 2022

Figure 2. India's Export Comparative Statement: APEDA Products

Preliminary figures from DGCI&S [***see Figure 2***] show that processed fruits and vegetables climbed by 42.42 percent from April to September 2022 compared to the same months the previous year, while fresh fruits increased by 4%. Additionally, compared to the first half of the prior year, processed food items including cereals and other processed goods saw an increase of 29.36 percent[10].

[10] *Ibid.*

April-September (2021-22)				
PRODUCTS	***April-September (2021-22)***			***Unit Value***
	QTY In MTs	***VALUE***		***(In USD Per Tonne)***
		Rs. Crores	***US$ Mil.***	
SCHEDULE PRODUCTS				
A. FLORICULTURE	11211	368	50	**4435**
B. FRUIT & VEGETABLE SEEDS	6708	486	66	**9810**
FLORICULTURE & SEEDS		**854**	**116**	
A. FRESH FRUITS	418514	2230	301	**720**
B. FRESH VEGETABLES	1371885	3220	435	**317**
FRUITS & VEGETABLES		**5450**	**737**	
A. PULSES	13449	999	135	**1006**
B. PROCESSED VEGETABLES	157267	1581	214	**1359**
C. PROCESSED FRUITS & JUICES	300148	2737	370	**1233**
PROCESSED FRUITS & VEGETABLES		**5317**	**719**	
A. BUFFALO MEAT	536957	11775	1594	**2968**
B. SHEEP/GOAT MEAT	4238	217	29	**6916**
C. ANIMAL CASINGS	6425	217	29	**4568**
D. PROCESSED MEAT	269	6	1	**2872**
E. OTHER MEAT	734	17	2	**3095**
F. POULTRY PRODUCT	NA	228	31	NA
G. DAIRY PRODUCTS	75989	1600	216	**2849**
LIVESTOCK PRODUCTS		**14059**	**1903**	
A. GROUNDNUTS	194994	1823	246	**1264**
B. GUARGUM	158958	1322	179	**1125**
C. CEREAL PREPARATIONS	201824	2328	315	**1560**
D. COCOA PRODUCTS	13217	553	75	**5662**
E. MILLED PRODUCTS	264102	837	113	**429**
F. ALCOHOLIC BEVERAGES	97783	990	134	**1369**
H. MISC. PROCESSED ITEMS	NA	4214	570	NA
OTHER PROCESSED FOODS		**12069**	**1632**	
A. BASMATI RICE	1945526	12268		**853**
B. NON-BASMATI RICE	8225622	21951		**361**
C. WHEAT	2376192	4656		**265**
D. OTHER CEREALS	1794818	3454		**260**
CEREALS		**42329**	**5726**	
TOTAL (Excluding Cashew)		**80078**	**10832**	
A. CASHEW KERNELS	46043	1642	222	**4822**
B. CASHEW NUT SHELL LIQUID	2166	14	2	**873**
CASHEW		**1656**	**224**	
TOTAL (Including Cashew)		**81734**	**11056**	

Table 1.1 Statement for Export of Agri and Processed Food Products [April-September (2021-22)]

April-September (2022-23)				
PRODUCTS	*April-September (2022-23)*			*Unit Value*
	QTY	*VALUE*		*(In USD*
	In MTs	*Rs. Crores*	*US$ Mil.*	*Per Tonne)*
SCHEDULE PRODUCTS				
A. FLORICULTURE	11479	386	49	**4286**
B. FRUIT/VEGETABLE SEEDS	9124	575	73	**8004**
FLORICULTURE & SEEDS		**960**	**122**	
A. FRESH FRUITS	409433	2438	313	**766**
B. FRESH VEGETABLES	1615800	3456	440	**272**
FRUITS & VEGETABLES		**5894**	**753**	
A. PULSES	394931	2580	330	**834**
B. PROCESSED VEGETABLES	187181	1997	254	**1357**
C. PROCESSED FRUITS/JUICES	318142	3471	441	**1385**
PROCESSED FRUITS & VEGETABLES		**8048**		
A. BUFFALO MEAT	577671	12834	1637	**2833**
B. SHEEP & GOAT MEAT	4870	265	34	**6944**
C. ANIMAL CASINGS	6368	203	26	**4070**
D. PROCESSED MEAT	202	8	1	**4911**
E. OTHER MEAT	731	18	2	**3186**
F. POULTRY PRODUCT	NA	444	57	**94.65**
G. DAIRY PRODUCTS	91402	2681	342	**3746**
LIVESTOCK PRODUCTS		**16454**	**2099**	
A. GROUNDNUTS	195108	1919	246	**1259**
B. GUARGUM	222281	2695	344	**1546**
C. CEREAL PREPARATIONS	224565	2822	359	**1600**
D. COCOA PRODUCTS	15815	583	74	**4705**
E. MILLED PRODUCTS	537391	1816	233	**433**
F. ALCOHOLIC BEVERAGES	105084	1262	161	**1529**
H. MISC. PROCESSED ITEMS	5457	695		
OTHER PROCESSED FOODS		**16553**	**2111**	
A. BASMATI RICE	2157091	17897	2280	**1057**
B. NON-BASMATI RICE	8956772	25191	3207	**358**
C. WHEAT	4590260	11562	1487	**324**
D. OTHER CEREALS	1529793	4112	525	**243**
CEREALS		**58762**	7499	
TOTAL (Excluding Cashew)		**106671**	13609	
A. CASHEW KERNELS	21135	1231	157	**7433**
B. CASHEW NUT SHELL LIQUID	5170	40	5	**984**
CASHEW		**1271**	**162**	
TOTAL (Including Cashew)		**107942**	**13771**	

Table 1.2. Statement for Export of Agri and Processed Food Products [April-September (2022-23)]

COMPARATIVE STATEMENT REGARDING EXPORT OF AGRI AND PROCESSED FOOD PRODUCTS April-September (2022-23) VIS-À-VIS PREVIOUS YEAR (Based on Provisional Data)			
% Change		*% Share in APEDA's total Export*	
Rs.	*USD*	*Rs.*	*USD*
4.85	-1.05	0.36	0.36
18.19	10.98	0.53	0.53
12.45	5.80	0.89	0.89
9.36	4.04	2.26	2.28
7.33	0.94	3.20	3.19
8.16	2.21	5.46	5.47
158.21	143.65	2.39	2.39
26.32	18.82	1.85	1.84
26.82	19.05	3.22	3.20
51.36	42.42	7.46	7.44
8.99	2.69	11.89	11.88
22.22	15.38	0.25	0.25
-6.45	-11.69	0.19	0.19
36.43	28.42	0.01	0.01
7.78	2.54	0.02	0.02
94.65	83.13	0.41	0.41
67.63	58.17	2.48	2.49
17.03	10.29	15.24	15.24
5.25	-0.34	1.78	1.78
103.86	92.14	2.50	2.50
21.18	14.09	2.61	2.61
5.38	-0.56	0.54	0.54
116.89	105.51	1.68	1.68
27.44	20.05	1.17	1.17
29.48	21.91	5.06	5.05
37.16	29.36	15.34	15.33
45.88	37.36	16.58	16.55
14.76	8.03	23.34	23.29
148.32	136.05	10.71	10.80
19.06	12.29	3.81	3.81
38.82	30.97	54.44	54.46
33.21	25.63	98.82	98.82
-25.06	-29.25	1.14	1.14
186.60	168.95	0.04	0.04
-23.27	-27.57	1.18	1.18
32.06	24.55	100.00	100.0

Table 1.3 Comparative Statement regarding Export of Agri and Processed Food Products

The APEDA's export statement for April-September 2022 *[see Table 1.1]* gives insights on India's agricultural exports during the first half of the fiscal year 2022-23. [*see Table 1.2]*[11].According to the data, the total value of India's agricultural exports during the April-September period of 2022 was USD 22.56 billion, which represents a growth of 15.36% compared to the same period last year. This indicates that India's agricultural exports are continuing to contribute significantly to the country's external trade and economy. [*see Table 1.3]*. Top agricultural commodities exported by India during the first half of the fiscal year were Basmati Rice, Non-Basmati Rice, Buffalo Meat, Sugar, and Groundnut, according to the statistics as well. These products help to explain a significant amount of India's total export earnings and show the value of agriculture to its foreign trade. Moreover, connected to the internal Indian agricultural output are the exports of these products. Export of Basmati and non-basmati rice, for example, highlights the importance of rice farming in India, a staple food crop and main source of income for millions of people. The export of Buffalo Meat also emphasizes in India's agricultural scene the importance of animal farming and rearing. The information from the April–September 2022 export statement underlines the ongoing importance of India's agricultural exports to its external trade and economy. It also emphasizes how important agriculture is to India's domestic economy, especially in relation to animal farming and the production of staple food crops.

III. Efforts & Initiatives By The Indian Government To Boost The Agricultural Sector

A. Schemes and Policies adopted by Indian Government to boost its Agricultural Sector

Being a State-subject[12], agriculture is mostly under the responsibility of the State Government for the expansion and development of the sector as well as for developing future plans for their particular States and guaranteeing efficient execution of the programs and schemes. Nonetheless, the Indian government helps the efforts of the State Governments by means of several schemes and projects.[13] The Indian government has launched many projects aiming at harmonising plant breeding developments with environmental sustainability and agricultural output. These initiatives are meant to guarantee that agriculture stays both viable and ecologically benign given the increasing pressures of climate change, declining soil fertility, and financial constraints experienced by farmers. Policies and programs aimed at supporting sustainable farming methods, the use of high-yielding, climate-resilient crop varieties, and the avoidance of environmentally harmful practices including stubble burning have been instituted. Comprising part of India's *National Action Plan on Climate Change, the National Mission for Sustainable Agriculture (NMSA)* is one of the flagship initiatives in this sense. This program supports organic farming, stresses climate-resilient farming methods, and advances agriculture to safeguard water supplies and soil quality. NMSA helps farmers adopt sustainable cropping patterns that guarantee long-term agricultural output while reducing environmental damage by combining technology with conventional knowledge systems.[14] Concurrent with this, the *Pradhan Mantri Krishi Sinchayee Yojana (PMKSY)* has

[11] APEDA, *Comparative Statement for Export of Agri and Processed Food Products* (2023), *available at:* https://apeda.gov.in/apedawebsite/Statistics/Comparative_Export_Statement_April_January_2021_22.pdf (last visited on Dec. 12, 2024).
[12] The Constitution of India 1950, art. 246, sch. VII, list II, entry 14.
[13] Ministry of Agriculture & Farmers Welfare, Contribution of Agriculture Sector Towards GDP, Press Information Bureau (2023).
[14] Government of India, National Mission for Sustainable Agriculture (NMSA), *available at:* https://nmsa.gov.in (last visited on Dec. 14, 2024).

been quite important in encouraging effective water use via drip and sprinkler irrigation. PMKSY guarantees that farmers can maximise water use since India's agricultural industry depends mostly on monsoon rains, so reducing farming vulnerability to irregular rainfall patterns.[15]

Launched the *Paramparagat Krishi Vikas Yojana (PKVY)*, which seeks to promote organic farming via cluster-based methods, the government hopes to lessen reliance on chemical fertilisers and pesticides. By lowering the negative environmental impact of chemical-intensive farming, this project not only promotes soil preservation but also reinforces India's commitment to sustainable agriculture. Furthermore, encouraging organic farming under PKVY fits the government's larger goal of preserving native seed varieties, which are vital for sustainable plant breeding.[16] Understanding the demand for high-yield, climate-resilient, and pest-resistant crops, the Indian Council of Agricultural Research (ICAR) has led breeding projects to create better crop varieties. Together with later programs for seed development, the National Seed Policy (2002) has guaranteed that Indian farmers have access to scientifically tested, premium seeds that maximise yield while lowering input costs. With the Biotech-KISAN program helping to combine modern plant breeding methods with conventional farming knowledge, research in genetic modification and biotechnology has progressed these objectives even more.[17]

The government has launched a suite of policy interventions to handle the urgent problem of stubble burning, which greatly aggravates air pollution and environmental damage. Among these are financial subsidies for the Happy Seeder machine, which allows residue-free sowing, and the Pusa Decomposer, a microbial solution meant to hasten crop residue breakdown. Economic and logistical restrictions force stubble burning even with legal actions under the National Green Tribunal (NGT) and the Air (Prevention and Control of Pollution) Act, 1981. These interventions, however, show a changing policy framework that tries to strike a compromise between environmental needs and the financial reality farmers deal with.[18] In agricultural research and innovation, the government has also aggressively supported public-private partnerships (PPPs). The state has pushed investment in biofortified crops, precision farming methods, and smart irrigation systems by working with private businesses, agricultural colleges, and research institutes. These partnerships have improved research as well as helped sustainable agricultural technologies to be commercially scalable.

Furthermore, the government is looking at ways to include biofuels into India's energy system by means of focused projects like the National Bio-Energy Mission, so providing farmers with an alternative to stubble burning by profit-making from crop wastes.[19] Although great progress has come from these initiatives, it is still difficult to guarantee general acceptance of sustainable farming methods. Lack of financial resources, mechanisation, and scientific knowledge among many small and marginal farmers limits their capacity to change towards ecologically sustainable farming practices. Furthermore,

[15] Ministry of Jal Shakti, "Pradhan Mantri Krishi Sinchayee Yojana", *available at*: https://pmksy.gov.in **(**last visited on Mar. 08, 2025).
[16] Ministry of Agriculture, "Paramparagat Krishi Vikas Yojana (PKVY)", *available at*: https://agricoop.nic.in (last visited on Nov. 25, 2024).
[17] ICAR, "Seed Research & Policy", *available at*: https://icar.org.in (last visited on Jan. 17, 2025).
[18] National Green Tribunal, "Crop Residue Management and Stubble Burning", *available at*: https://greentribunal.gov.in (last visited on Sep. 03, 2024).
[19] Department of Biotechnology, "Biotech-KISAN Scheme", *available at*: https://dbtindia.gov.in (last visited on Feb. 28, 2025).

grassroots policy implementation sometimes runs across bureaucratic and infrastructure problems. A more integrated strategy combining incentives, technological developments, and farmer education is crucial going forward if Indian agriculture is to be sustainable over long run. Thus, the secret to success is making sure that agricultural productivity, environmental preservation, and economic development are seen as complementary forces promoting rural transformation rather than as conflicting goals.

B. Impacts of the Government Initiatives

Several structural and operational difficulties still exist notwithstanding the multifarious efforts of the Indian government to strike a balance between environmental preservation, plant breeding developments, and agricultural productivity. These problems span policy implementation gaps and financial limitations to technological accessibility and farmer socio-economic opposition. Dealing with these issues calls for an all-encompassing plan combining institutional support, scientific study, and grassroots-level policy implementation to guarantee that economic viability and sustainability coexist. Among small and marginal farmers, who account for over 80% of India's farming population, one of the main obstacles is their limited acceptance of sustainable agricultural methods. Although programs like the *Paramparagat Krishi Vikas Yojana* (PKVY) and the National Mission for Sustainable Agriculture (NMSA) support organic and climate-resilient farming, their influence is sometimes limited by poor extension services and ignorance. The great initial expenses of switching to sustainable methods have many farmers still reliant on conventional farming methods. For example, although mechanised substitutes like the Happy Seeder and Pusa Decomposer provide good solutions for stubble management, their availability is still low because of logistical constraints and pricing problems.[20]

For farmers using diversified crops or biofuel generation, market linkages and price volatility also create problems. The lack of guaranteed markets for alternative crops like millets, pulses, and oilseeds discourages farmers from switching even if the government promotes crop diversification to lower reliance on paddy-wheat monoculture. Moreover, although the generation of biofuel from crop wastes presents a good substitute, insufficient storage and processing facilities compromise its commercial feasibility, resultantly discouraging industrial investments in biomass-based energy.[21] Intensive farming and too high chemical fertiliser use aggravate soil degradation and declining water tables, another major problem. Short-term yield concerns force many farmers to overuse chemical inputs even with the Soil Health Card Scheme and attempts to encourage balanced fertilisation. Likewise, groundwater depletion is still a major problem particularly in Punjab, Haryana, and western Uttar Pradesh, where unsustainable water consumption results from free or subsidised electricity for irrigation. Further aggravating the situation are lax rules on groundwater use and over-reliance on high-yielding, water-intensive varieties.[22] Furthermore posing major bureaucratic challenges and fragmentation between central and state authorities is grassroots policy implementation. In India, agricultural governance is mostly dispersed and states have great control over policy execution. Delays and inefficiencies follow from often inconsistent central directions and state-level execution. For example, although there are

[20] Indian Ministry of Agriculture, "Sustainable Agricultural Practices & Government Schemes", *available at*: https://agricoop.nic.in (last visited on Apr. 02, 2025).
[21] NITI Aayog, "Market Integration & Crop Diversification in Indian Agriculture", *available at*: https://niti.gov.in (last visited on Apr. 02, 2025).
[22] Central Ground Water Board, "Groundwater Depletion in India: Causes and Solutions", *available at*: https://cgwb.gov.in (last visited on Apr. 04, 2025).

subsidies for residue management equipment, bureaucratic red tape often delays their disbursal, thereby lessening their efficacy in discouraging stubble burning.[23]

C. Traversing the Obstacles: Varied Approaches

Overcoming these obstacles requires an integrated and multi-stakeholder approach going ahead. Encouragement of sustainable practices depends much on strengthening agricultural extension services to improve farmer knowledge and awareness. By enabling small and marginal farmers to invest in diversified and climate-resilient agricultural practices, increasing access to institutional credit and insurance programs helps to remove financial obstacles. Furthermore, the use of technological developments in plant breeding and precision agriculture has to be maximised to improve output and control resources. Supported by research organisations such as ICAR, the creation of drought-resistant, biofortified, and high-yielding crop varieties will prove essential in guaranteeing food security while lowering environmental stress. Furthermore, increasing public-private cooperation in agri-tech can potentially help to hasten the implementation of contemporary farming technologies including real-time soil monitoring and AI-driven irrigation systems, so improving sustainability.[24] Furthermore essential to ensuring that crop diversification becomes financially feasible is improving market infrastructure and value chain integration. Minimising monoculture reliance by means of minimum support prices (MSP) for alternative crops, enhancing post-harvest storage facilities, and supporting contract farming models can inspire farmers to stray from monoculture reliance. Simultaneously, encouraging businesses to make investments in biomass-based fuel and renewable energy can provide farmers with other income sources and help to lower agricultural waste.[25] Additionally, simplified government structures and policy coherence are absolutely necessary. Together with an active stakeholder involvement, including farmer cooperatives, research institutes, and industry players, the junction of central and state-level agricultural policies guarantees that policy frameworks translate successfully into on-ground action.

IV. STAKEHOLDERS' PERSPECTIVES

A. Technological Accessibility and Economic Concerns

Two of the several policies the Indian government has implemented to help farmers are the PM-KISAN scheme, which provides direct income support, and the PMFBY policy, which seeks to lower the risks related with crop failures. But poor bureaucracy and varying implementation often compromise their efficiency. The data of the study indicates that PM-KISAN has enhanced the short-term financial stability of small farmers; its long-term consequences on general production are yet unknown. Modern agricultural practices have significantly transformed farming in India, leading to increased productivity and efficiency. The adoption of high-yield variety (HYV) seeds, mechanized farming techniques, and precision agriculture has revolutionized traditional farming methods. However, these advancements come with challenges, particularly concerning economic viability and

[23] National Green Tribunal, "Challenges in Policy Implementation for Crop Residue Management", *available at*: https://greentribunal.gov.in (last visited on Apr. 04, 2025).
[24] Indian Council of Agricultural Research, "Advances in Plant Breeding and Precision Agriculture", *available at*: https://icar.org.in (last visited Mar. 28, 2025).
[25] Ministry of New & Renewable Energy, "Bio-Energy & Biomass-Based Fuel Initiatives in India", *available at*: https://mnre.gov.in (last visited on Apr. 04, 2025).

sustainability. One of the major concerns expressed by farmers of the selected States is the 'increasing cost of modern farming techniques' and the 'insufficient funding support' by the government in furtherance of its schemes and policies.

B. Environmental Concerns Related to Intensive Farming

The intensification of farming practices has raised significant environmental concerns, particularly in the three selected regions of the study. The excessive use of chemical fertilizers and pesticides has led to soil degradation and water contamination. According to recent government reports, groundwater depletion in Punjab is occurring at an alarming rate due to the continuous cultivation of water-intensive crops like paddy. A farmer from Punjab commented, "पहले हमारी ज़मीन बहुत उपजाऊ थी, लेकिन अब लगातार खाद और कीटनाशकों के उपयोग से मिट्टी की उर्वरता कम हो रही है।" ("Our land used to be very fertile, but continuous use of fertilizers and pesticides has reduced soil fertility.") This decline in soil quality has forced farmers to use even more chemical inputs, creating a vicious cycle of dependency. Additionally, stubble burning has been a persistent issue, contributing to severe air pollution in North India. Government regulations to curb this practice have seen limited success, as farmers often find alternative disposal methods financially unviable. For instance, recently, the Punjab government issued a directive to the Punjab brick-kiln owners to replace 20% of the coal they use to burn the furnaces in their kilns with paddy-straw pellets. This initiative was taken to address the issue of stubble burning in Punjab. However, the brick kiln owners in this area, *via* Punjab Brick Kiln Owner's Association (PBKOA) filed a case before the Supreme Court seeking stay to be imposed upon this action.[26] They pleaded that the transition would require a lot of 'initial capital investment' and 'technical changes' in the brick kiln furnace structures. Another issue highlighted by them is the issue of 'accessibility'. There is no established network for paddy straw pellets' supply, currently. Wherever it is available, it is charged at a higher rate due to lack of availability, thereby putting an additional financial strain upon the brick kiln operators and owners. It has also been emphasised that since this 20% transition would gradually be moved to 100%, the established network of coal suppliers would suffer a major setback. Many will lose their primary source of livelihood. Thus, this issue highlights the need to understand the perspectives of those affected adversely, even though the policy objective aims at environmental sustainability.

Acknowledging this dilemma of protecting the environment on one hand and the stakeholders on the other, the Court passed an order granting interim relief to the PBKOA in the matter till the time the government does not come up with the solutions it will employ to tackle these issues.[27] After the association protested the mandatory mixing of paddy straw pellets with coal, the order has been passed with the intention of averting any negative action to close brick kilns linked with the association.[28] These results demonstrate the pressing need for sustainable farming practices, including crop diversification, organic farming, and water conservation. To encourage broad adoption, policies that support these practices should be strengthened with monetary rewards and technical support. The analysis emphasises that although contemporary farming methods have increased productivity, their long-term viability is still in doubt. For Indian agriculture to remain resilient in the future, a well-

[26] Punjab & Haryana High Court Order, W.P. (C) No. 2756/2023 (Feb. 14, 2023).
[27] *Ibid.*
[28] "Supreme Court Rejects Plea to Direct Punjab and Haryana Govts to Control Stubble Burning" *The Hindu*, Mar. 30, 2025.

rounded strategy that includes environmental preservation, policy reform, and economic assistance is necessary.

C. Socio-Economic Conditions of Farmers in the Selected States

There are notable differences in the socioeconomic circumstances of farmers in Punjab, Haryana, and Uttar Pradesh according to factors like landholding patterns, income levels, educational attainment, and access to agricultural resources. Assessing the difficulties farmers face and the effects of agricultural policies requires an understanding of these circumstances. Compared to Haryana and Uttar Pradesh, Punjab, which is frequently referred to as the "Granary of India," has a comparatively higher percentage of large landholders. According to data from the field survey, most Punjabi farmers own between two and five hectares of land, while a small minority own holdings larger than ten hectares. The distribution of land in Haryana, on the other hand, is somewhat more dispersed, with a higher proportion of small and marginal farmers (less than 2 hectares). With more than 70% of farmers surveyed having landholdings under two hectares, Uttar Pradesh, the most populous agrarian state, has the largest percentage of smallholder farmers. Access to credit facilities, economic security, and productivity levels are all impacted by this discrepancy.

The three states' income distributions differ greatly, with Punjab having the highest average household agricultural income. According to empirical data, the average farm income in Punjab is roughly INR 2,50,000 per year, while it is INR 1,80,000 in Haryana and INR 1,20,000 in Uttar Pradesh. Differences in cropping practices, mechanisation, and access to high-yield inputs are the causes of this discrepancy. Even with Punjab's higher incomes, rising production costs and mounting debt are still major problems. Decision-making in agriculture and the adoption of new technologies are significantly influenced by educational attainment. According to the survey results, 58% of farmers in Haryana and nearly 65% of farmers in Punjab have completed formal education up to the secondary level or higher. Just 45% of farmers in Uttar Pradesh have completed secondary school, making it the state with the lowest educational attainment. Farmers' knowledge of agricultural programs, financial literacy, and capacity to bargain for fair prices for their produce are all directly impacted by this lack of formal education. One of the most important problems is still access to agricultural resources, such as credit, irrigation, and extension services. 75% of farmers in Punjab say they have access to formal credit facilities, compared to 48% in Uttar Pradesh and 62% in Haryana. Investment in improved infrastructure and farming methods is heavily influenced by institutional credit. Furthermore, whereas a sizable percentage of farmers in Uttar Pradesh continue to use conventional farming practices, Punjab and Haryana enjoy greater degrees of mechanisation. Although Punjab's socioeconomic indicators are generally better, issues like growing debt, diminishing groundwater levels, and stagnating yields are cause for grave concern. Though its landholding patterns are more dispersed, Haryana faces comparable difficulties. However, Uttar Pradesh is the most vulnerable of the three states due to its high reliance on subsistence farming, low levels of income, and limited mechanisation.

V. POLICY GAPS AND RECOMMENDATIONS FOR IMPROVEMENT

India's agricultural sector has undergone notable governmental interventions throughout the years; nonetheless, the effectiveness of these initiatives has been constrained by certain crucial voids not filled. Among the key policy defects are inadequate environmental protections, inadequate technology distribution, and inadequate financial support systems. These voids have to be closed if we are to ensure a more strong and

sustainable farming system. Programs like the PM-KISAN provide direct financial aid to farmers; yet, the amount offered usually is not sufficient to match rising production expenses. Research indicates that more than 60% of small-scale farmers struggle to pay for their input expenses despite financial aid.[29] Changing subsidies based on regional cost variations and inflation patterns would assist to ensure that small and marginal farmers receive adequate support. Another big problem is the poor implementation of crop insurance schemes, particularly the PMFBY. Sometimes farmers choose different ideas because complicated governmental processes and long claim settlements discourage them. Less than 30% of eligible farmers, according to research, properly receive claims within the designated term.[30] Simplifying the claim settlement procedure and increasing openness in insurance transactions would help to considerably increase farmer confidence and involvement rates. Another critical issue is "technological dissemination." Though its acceptability among small and marginal farmers is currently restricted due of significant initial investment costs and inadequate digital literacy, digital farming and precision agriculture could alter agricultural productivity. The Digital India project has made tremendous progress in advancing online agricultural services, even if statistics suggests that just 35% of rural farmers have enough digital literacy.[31] Implementing training programs for rural farmers and enhancing subsidies for precision farming technologies will mitigate this disparity. Existing policy frameworks continue to inadequately tackle environmental challenges. In Punjab and Haryana, excessive dependence on chemical fertilisers and pesticides has led to significant soil deterioration and groundwater depletion.[32]

Policies ought to endorse organic farming techniques and provide financial incentives to farmers adopting sustainable practices, such as crop rotation and bio-fertilizers. Moreover, stubble burning remains an ongoing issue despite governmental regulations. The existing regulations have not provided commercially viable alternatives to residue burning, resulting in considerable air pollution across North India.[33] Expanding subsidies for bio-decomposer technologies and encouraging industrial use of crop wastes—which will turn into organic manure or biofuels—is advised policy direction.

VI. Analysis of Factors Affecting Development of the Agricultural Sector

A. Employment

[29] Agricultural Policy Report, "PM-KISAN Study", *available at:* https://www.agripolicyreport.in/PM-KISAN-study (last visited on Apr. 04, 2025).
[30] National Bank for Agriculture and Rural Development (NABARD), "PMFBY Analysis", *available at*: https://www.nabard.org/PMFBY-analysis (last visited on Apr. 01, 2025).
[31] Dennis Junior Choruma, *et.al.*, "Digitalisation in Agriculture: A Scoping Review of Technologies in Practice, Challenges, and Opportunities for Smallholder Farmers in Sub-Saharan Africa" 18 *Journal of Agriculture and Food Research* 101286 (2024), *available at*: https://doi.org/10.1016/j.jafr.2024.101286 (last visited on Mar. 20, 2025).
[32]Indian Council of Agricultural Research (ICAR), "Soil Health Report", *available at*: https://www.icar.gov.in/soil-health-report (last visited on Feb. 01, 2025).
[33] Central Pollution Control Board, *Stubble Burning Report*, *available at*: https://www.cpcb.gov.in/stubble-burning-report (last visited on Feb. 04, 2025).

India has the world's second-largest agricultural land area, with agriculture providing a living for about 60% of rural Indian households. Half of the workforce in India works in the agricultural sector, and we are incredibly reliant on farmers to provide us with food. However, on the basis of the data gathered from the regions of Punjab, Haryana and Uttar Pradesh in the year 2024, there appears to be a discouraging attitude of the present generations of farmer, when questioned about their willingness to continue their family baton and pursue agriculture as a primary occupation. It was found that out of 729 farmers interviewed from these regions, 48% have no interest in keeping agriculture as a primary source of their livelihood; 16% have no willingness to even pursue it as their secondary occupation; while only 36% of them showed interest in taking agriculture as their primary occupation ***[See figure 3]***. Upon enquiry, it was observed that the farmers have lost faith in the government and its policies, which according to them solely exist on paper. Most of the farmers and landholders in the villages presented disaffection towards the ununiform transmission of knowledge to the people engaging in agriculture. The information either reaches the ears of big landholders or the prosperous villages, but does not trickle down most often to the small landholders, farmers or the remote villages of these States.

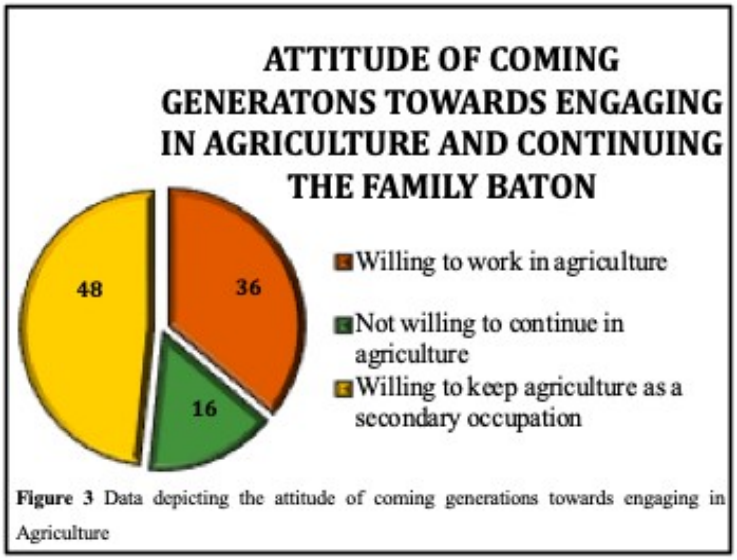


Figure 3 Data depicting the attitude of coming generations towards engaging in Agriculture

B. Income

With the advent of digitalization, the world has witnessed a very quick transformation. Even India has not remained bereft of its touch. The nation has also ushered into the digital space and allowed the gizmo of the digital construct to hover over all its sectors for years now, the agricultural sector being no exception to this. India is propelling its engines towards a progressive space, and has engaged in a long-running *tête-à-tête* with its farming infrastructure, practices and related communities from a long time now. The agricultural sector contributes approximately 20% to the national GDP. Even though the numbers keep changing, the contribution has never fallen out of the range of 13% to 20% (at least in the past 5 years) which is still quite significant. As per the Economic Survey (2021-22): "Agriculture and allied sectors expected to grow by 3.9 percent; industry by 11.8 percent and services sector by 8.2 percent in 2021-22"[34]. It is estimated that India's agriculture sector accounts only for around 14 percent of the country's economy but for 42 percent of total employment.

As around 55 percent of India's arable land depends on precipitation, the amount of rainfall during the monsoon season is very important for economic activity. The Central Sector Scheme of Financing Facility under the Agriculture Infrastructure Fund (AIF) has been launched by the Indian government to support post-harvest management and community farming assets. Several efforts by the government have been made to boost the income of

[34] Ministry of Finance, "Key Highlights" (*Press Information Bureau*, 2024).

farmers, or to at least provide them with a certain level of income support[35]. PM-KISAN Scheme[36] is one such scheme that was implemented with the goal of providing income support to all landholding farmer families across the country, allowing them to meet domestic requirements as well as expenses related to agriculture and related activities[37]. With some exceptions, the Scheme, which became operational on December 1, 2018, proposed to compensate farmers' families with cultivable land holdings Rs. 6000 annually. Under the Direct Benefit Transfer mechanism, the Central Government transfers a cash benefit of Rs. 6000/- to eligible farmers' bank accounts in three four-monthly payments of Rs. 2000/- during the fiscal year. However, the farmers do not seem to be satisfied with the implementation of the scheme.

For instance, a farmer from Uttar Pradesh upon being questioned about his feedback regarding this scheme stated, "हमें साल में 6000 रुपये मिलते हैं, लेकिन यह इतनी बड़ी राशि नहीं है कि इससे खेती के बढ़ते खर्च पूरे हो सकें। सरकार को लागत के हिसाब से सहायता बढ़ानी चाहिए।" ("We receive ₹6,000 annually, but this amount is insufficient to cover the rising costs of farming. The government should increase support in proportion to expenses.") This sentiment reflects the financial strain that many farmers face despite government interventions like the PM-KISAN scheme. Similarly, access to crop insurance under Pradhan Mantri Fasal Bima Yojana (PMFBY) has been a significant issue. A farmer from Haryana stated, "हमने बीमा योजना का लाभ उठाने की कोशिश की, लेकिन जब फसल खराब हुई तो क्लेम मिलना बहुत मुश्किल हो गया। कंपनियां बहाने बनाकर भुगतान नहीं करतीं।" ("We tried to avail the benefits of the insurance scheme, but when our crops failed, claiming compensation became incredibly difficult. Insurance companies make excuses and delay payments.") These responses highlight the practical difficulties faced by farmers despite the implementation of modern agricultural practices and government schemes. To enhance the effectiveness of these initiatives, policymakers need to ensure better financial support, transparent subsidy distribution, and streamlined insurance claim processes.

C. Technology

The transformation of rural India has been significantly driven by technological advancements, reshaping agriculture, finance, healthcare, education, and market access. Precision farming, enabled by technologies like remote sensing, GPS, and IoT-based monitoring, has enhanced productivity while optimizing resource use. Access to real-time weather updates and market data empowers farmers to make informed decisions, reducing risks and improving financial stability. Digital platforms and e-commerce have further revolutionized rural economies, providing direct access to larger markets and minimizing reliance on intermediaries.[38] Financial inclusion has also expanded through mobile banking and digital payment systems, allowing rural communities to access credit and conduct cashless transactions. Government initiatives such as BharatNet and Digital India have played a crucial role in improving internet penetration, bridging the rural-urban digital divide. Meanwhile, telemedicine and mobile health clinics have made healthcare more accessible,

[35] Ministry of Agriculture & Farmers Welfare, "Contribution of Agriculture Sector towards GDP" (Press Information Bureau, 2024).
[36] Ministry of Agriculture and Farmers Welfare, "PM-Kisan Scheme" (*PM-Kisan*, 2024).
[37] *Ibid.*
[38] M.S.T. Abbas, "Genetically engineered (modified) crops (*Bacillus thuringiensis crops*) and the world controversy on their safety" 28 *Egyptian Journal of Biological Pest Control* (2018); *available at*: https://ejbpc.springeropen.com/articles/ 10.1186/s41938-018-0051-2 (last visited Apr. 06, 2024).

reducing the need for long-distance travel. Digital learning platforms and skill development programs are equipping rural youth with the necessary competencies for employment, fostering diversification beyond traditional agriculture. Despite these advancements, challenges remain. High costs and limited digital literacy often hinder the widespread adoption of technology. Small-scale farmers, in particular, struggle with affordability and accessibility, creating disparities in agricultural benefits. Over-reliance on technology also raises concerns about biodiversity loss, environmental degradation, and the concentration of economic power among a few dominant corporations.[39] However, when implemented inclusively and sustainably, technology holds immense potential to uplift rural communities. Precision farming can enhance yields and reduce input costs, while digital platforms can ensure fair pricing and better market access. The key lies in adopting an equitable approach that prioritizes smallholder farmers and rural entrepreneurs, ensuring that technological progress translates into holistic and long-term rural development.

D. Investment

Modern agriculture necessitates significant government intervention to uphold the quality and safety standards required for global market competitiveness. This objective should be achieved by strengthening the secondary sectors, such as agricultural processing and related industries, alongside the tertiary sectors, which encompass technical, commercial, and transportation services. By ensuring robust managerial, administrative, and consulting support, the government can create a more resilient and sustainable agricultural framework. Recognizing this need, the Indian government has undertaken multiple initiatives aimed at enhancing institutional lending, improving agricultural infrastructure, and extending financial assistance to farmers.[40] (***See figure 4:*** **Expenditure of the Ministry*).*** One of the key pillars supporting agricultural growth is institutional lending, which provides farmers with access to credit for essential investments in farm inputs, mechanization, and modernized cultivation techniques. To facilitate this, the government has established the National Bank for Agriculture and Rural Development (NABARD)[41], a specialized financial institution that plays a crucial role in agricultural and rural credit distribution. NABARD serves as a refinancing institution for banks and financial entities offering agricultural loans, enabling them to provide more accessible and affordable credit to farmers. Additionally, NABARD plays a pivotal role in capacity-building programs, financial literacy initiatives, and rural infrastructure development, all of which contribute to strengthening the agricultural sector.

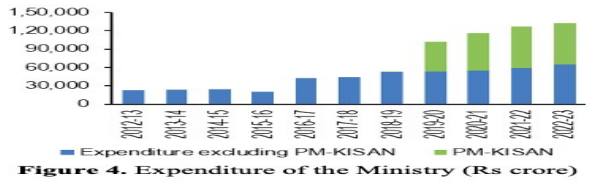


Figure 4. Expenditure of the Ministry (Rs crore)

Recognizing the need for timely and affordable credit, the government introduced the Kisan Credit Card (KCC) scheme, which provides farmers with a streamlined mechanism for accessing institutional credit. Under this scheme, farmers receive a credit card that enables them to secure loans from banks with minimal paperwork and reduced interest rates. This initiative has proven to be instrumental in addressing the liquidity needs of farmers, allowing them to procure seeds, fertilizers, and essential machinery without the constraints of high

[39] Lu Zhang, Chengxi Yan and others, "The impact of agricultural chemical inputs on environment: Global evidence from informetrics analysis and visualization" 13 I*TJLCT* (2018); *available at*: https://ejbpc.springeropen.com/articles/10.1186/s41938-018-0051-2 (last visited on Apr. 06, 2024).
[40] *Ibid.*
[41] National Bank for Agriculture and Rural Development, 'NABARD' (NABARD, 2023).

borrowing costs. Complementing this, the government also launched the Pradhan Mantri Mudra Yojana (PMMY), which aims to provide small and marginal farmers, along with micro and small entrepreneurs, with easy access to credit. The scheme categorizes loans into three tiers: Shishu, Kishore, and Tarun, based on the required loan amount, ensuring that different financial needs are met effectively. Through this structured approach, the PMMY has facilitated greater financial inclusion, enabling more farmers and agripreneurs to access the resources needed for growth and sustainability. To further reduce the financial burden on farmers, the government has implemented the Interest Subvention Scheme, which provides interest subsidies on short-term agricultural loans. This scheme helps farmers access credit at significantly lower interest rates, reducing their dependency on informal lending sources that often charge exorbitant interest. By incentivizing institutional borrowing, the scheme ensures that farmers are not deterred from making necessary investments in their agricultural operations. In addition, the government established the Rural Infrastructure Development Fund (RIDF) under NABARD, which provides financial support to state governments for rural infrastructure projects.[42] These projects, which include irrigation systems, rural roads, market yards, and storage facilities, are essential for improving agricultural productivity and ensuring seamless market access for farmers.

Beyond credit accessibility, the government has focused on providing direct financial assistance to farmers to stabilize their incomes and promote agricultural sustainability. The PM-KISAN scheme is a landmark initiative in this regard, offering small and marginal farmers direct income support of ₹6,000 annually, distributed in three equal instalments. This financial assistance is transferred directly to farmers' bank accounts, helping them meet input costs and sustain their livelihoods.[43] In parallel, the government continues to subsidize farm inputs such as seeds, fertilizers, agricultural machinery, and irrigation infrastructure, ensuring that modern agricultural tools and techniques remain within farmers' financial reach. These subsidies play a critical role in boosting productivity and making farming a more viable profession, particularly for smallholders.

Infrastructure development has also been a major focus of the government's agricultural policies. To modernize farming and enhance market efficiency, the government has established the Agri-Tech Infrastructure Fund, which promotes investments in advanced agricultural technologies. These investments support precision farming, digital platforms, and smart irrigation techniques, making agriculture more competitive and economically rewarding. Another significant development is the expansion of scientific warehousing and cold storage infrastructure. By extending the shelf life of perishable agricultural produce and reducing post-harvest losses, these facilities enable farmers to avoid distress sales and secure better market prices. The integration of advanced storage systems into the agricultural supply chain is particularly beneficial for small and marginal farmers, who often lack the resources to manage surplus produce effectively. Budgetary allocations for agriculture and rural development have reflected the government's commitment to these initiatives. In the financial year 2022–23, the Ministry of Agriculture and Farmers' Welfare was allocated ₹1,32,514 crore, a 4.5% increase from the revised estimates of ₹1,26,808 crore in 2021–22. Notably, 55% of this budget, amounting to ₹68,000 crore, was directed toward the PM-KISAN scheme, highlighting the government's prioritization of direct income support to farmers. The remaining ₹64,514 crore was distributed across various agricultural programs, including crop insurance schemes, interest subvention programs, and infrastructure

[42] NABARD, "RIDF *(RIDF*, 2023)", *available at*: https://www.nabard.org/content1.aspx?id=573&catid 8&mid=488 (last visited on Mar. 13, 2025).
[43] Ministry of Agriculture and Farmers Welfare, "PM-Kisan Scheme" (*PM-Kisan*, 2024).

development initiatives. These budgetary allocations underscore the government's recognition of agriculture as a critical sector that requires sustained investment and policy support.

The cumulative impact of these initiatives has been instrumental in strengthening India's agricultural landscape. By integrating financial assistance, institutional lending, infrastructure expansion, and digital transformation, the government has created a more robust and inclusive agricultural framework. However, challenges persist, including the digital literacy gap among farmers, limited accessibility of formal credit for landless laborers, and inefficiencies in post-harvest supply chains. Addressing these challenges through policy refinements, better financial literacy programs, and expanded rural infrastructure will be essential for ensuring long-term agricultural sustainability. Moving forward, a balanced approach that combines technological innovation, financial inclusivity, and environmental sustainability will be crucial in transforming India's agriculture sector and securing the livelihoods of millions of farmers.

E. Plant Breeding

Rural diversification in India has significantly influenced plant breeding, expanding its focus beyond staple crops to include pulses, oilseeds, millets, fruits, and vegetables. This shift has led to the development of crop varieties with improved nutritional profiles, disease resistance, and adaptability to diverse agro-climatic conditions. Farmers' involvement in participatory breeding programs ensures varieties align with local needs and market demands. Additionally, with the rise of organic and sustainable farming, breeders now prioritize crops with natural pest resistance, nutrient-use efficiency, and adaptability to low-input systems. Consumer preferences, including taste, texture, and cooking qualities, are also increasingly factored into breeding strategies. Overall, these advancements support agricultural resilience, sustainability, and food security in India. The impact of plant breeding is evident in various successful crop varieties. Bt cotton**,** genetically modified to resist bollworms, has significantly reduced pesticide use and increased yields. Pusa Basmati rice, developed by the Indian Agricultural Research Institute (IARI), is highly valued for its aroma, grain length, and export potential. Arka varieties such as Arka Rakshak (tomato) and Arka Kesar (mango) offer disease resistance and higher productivity. HYV wheat varieties like Kalyan Sona and HD 2967, introduced during the Green Revolution, revolutionized wheat production. Hybrid maize variants such as HM4 and HM9 have enhanced yields and pest resistance, supporting animal feed and industrial uses. Pusa Giant Napier Grass has improved fodder availability, benefiting the livestock sector. These breeding innovations have played a crucial role in enhancing farm productivity and rural incomes.

The Indian government has implemented various initiatives to strengthen plant breeding and agricultural research. The National Agriculture Innovation Fund (NAIF)[44] provides financial support for agricultural innovators, encouraging research and technology transfer. The National Agricultural Research and Extension System (NARES)**,** including ICAR and State Agricultural Universities, advances plant breeding through institutional research. The Rashtriya Krishi Vikas Yojana (RKVY)[45] funds state-led agricultural research, promoting crop variety development. The National Agriculture Development Program (NADP) supports research, seed production, and breeding infrastructure. Additionally, the

[44] Agri-Innovate, 'ICAR National Agricultural Innovation Fund (NAIF) Review of Agri Business Incubators Horticulture Division' (ICAR, 2021).
[45] Ministry of Agriculture & Farmers Welfare, RKVY (*RKVY*, 2021).

National Food Security Mission (NFSM)[46] focuses on increasing food production by promoting high-yielding and disease-resistant crop varieties. These efforts collectively enhance breeding programs, ensuring sustainable agricultural growth and farmer welfare across India.

F. Access to Resources

Access to agricultural resources in India is extensive, yet disparities persist among stakeholders. To address this, the Indian government has introduced several schemes aimed at enhancing resource accessibility for farmers and promoting sustainable agricultural practices.

The PMFBY scheme[47] offers crop insurance to farmers, protecting them against losses due to natural calamities, pests, and diseases. This initiative aims to stabilize farmers' incomes and encourage the adoption of modern agricultural techniques. The PMKSY scheme[48] focuses on enhancing irrigation infrastructure and promoting efficient water use. By expanding irrigation coverage and improving water management practices, PMKSY seeks to increase crop productivity and ensure sustainable water utilization. To improve market access, the National Agriculture Market (e-NAM)[49] serves as a pan-India electronic trading platform, integrating existing Agricultural Produce Market Committees (APMCs). This platform facilitates transparent and efficient trading, enabling farmers to secure better prices for their produce.[50] The Soil Health Card Scheme[51] provides farmers with detailed assessments of their soil's nutrient status, along with recommendations for appropriate fertilizer use. This empowers farmers to make informed decisions, leading to enhanced soil fertility and increased crop yields. Under the National Mission for Sustainable Agriculture (NMSA)[52], efforts are made to promote climate-resilient and sustainable farming practices. The mission supports initiatives such as conservation agriculture, organic farming, and efficient water management to bolster agricultural productivity while mitigating climate change impacts.

The Paramparagat Krishi Vikas Yojana (PKVY) encourages organic farming through a cluster-based approach, providing financial assistance for organic inputs, certification, and marketing. This scheme aims to improve soil health, promote biodiversity, and produce chemical-free agricultural products. Despite these initiatives, challenges remain. Approximately 85% of Indian farmers cultivate less than or just five acres of land, with a significant portion being rainfed. These small-scale farmers contribute substantially to agricultural production, especially in high-value sectors like vegetables and milk.[53] Additionally, labor shortages for various farm operations are a growing concern nationwide.[54]

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[46] Ministry of Agriculture & Farmers Welfare, "National Agriculture Development Project to Give Farmers Assured Income" (*Press Information Bureau*, 2020).
[47] Ministry of Agriculture & Farmers Welfare, PMFBY, (PMFBY, 2022).
[48] Ministry of Agriculture & Farmers Welfare, PMKSY, (PMKSY, 2021).
[49] Ministry of Agriculture & Farmers Welfare, e-NAM, (*e-NAM*, 2024).
[50] National Agriculture Market, *available at*: https://enam.gov.in (last visited on Apr. 01, 2025).
[51] Dr. A. Amarender Reddy, *Impact Study of Soil Health Card Scheme* (MANAGE 2017) 210.
[52] Ministry of Agriculture & Farmers Welfare, 'National Mission for Sustainable Agriculture' (*NMSA*, 2019), *available at*: https://nmsa.dac.gov.in/ (last visited on Feb. 13, 2025).
[53] Ramesh Chand and S.K. Srivastava, "Changes in the Rural Labour Market and their Implications for Agriculture" 10 *Economic and Political Weekly* 47, 48 (2014).
[54] M. Satishkumar, and K.B. Umesh, "Farmers Strategies to Cope Labour Shortage in Northern and Southern Dry Zones of Karnataka, India" 6(2) *CARJ* 1 (2018).

Recognizing these issues, the government has established funds such as the Long-Term Irrigation Fund (LTIF) and the Micro Irrigation Fund to promote investment and growth in the agricultural sector. Awareness and literacy among farmers are crucial for the effective utilization of these resources. The present study indicates a direct correlation between literacy levels and awareness of governmental policies and schemes, highlighting the need for targeted educational programs to ensure equitable access to resources. Thus, while the Indian government has launched multiple schemes to enhance resource access for farmers, addressing challenges related to landholding sizes, labor availability, and farmer awareness is essential for achieving sustainable and inclusive agricultural development.

G. Awareness about the laws in Northern India

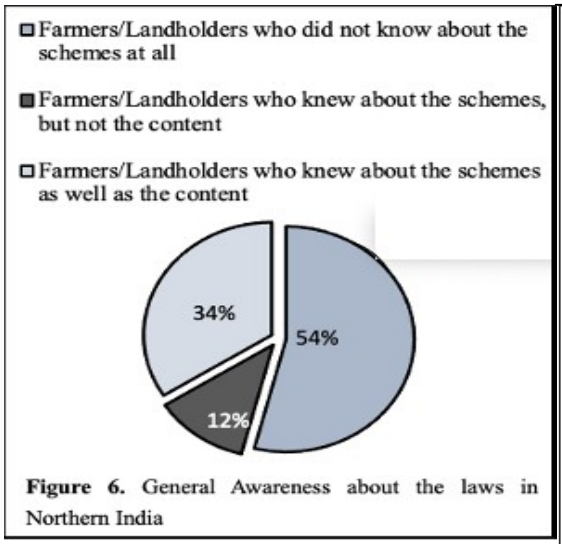

Figure 6. General Awareness about the laws in Northern India

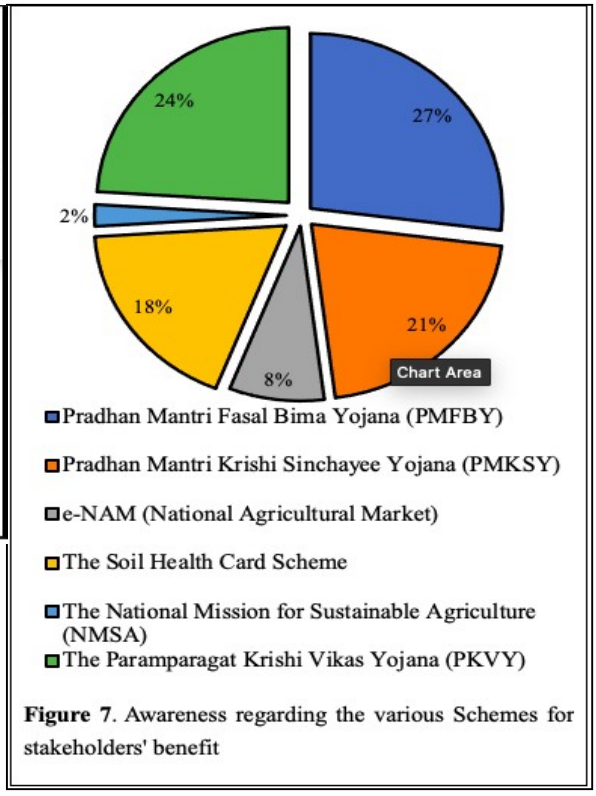

Figure 7. Awareness regarding the various Schemes for stakeholders' benefit

The agricultural boom that propelled India's transition to food self-sufficiency was sparked by the Green Revolution. The revolution began in the year 1968, leading to an increased production of food grain, in the regions of Punjab, Haryana and Uttar Pradesh.The momentum that food production in these areas gained from the revolution, is still responsible for the position they hold in today's economic set-up. During the course of this research, the researchers observed that throughout the belt of Punjab, Haryana and Uttar Pradesh, near to none of the farmers or agricultural labourer's knew about their rights under the law, or about the policies and schemes that government has introduced from time to time ***[See Figures 6:* General Awareness about the laws in Northern India,** ***7:* Awareness regarding the various Schemes for stakeholders' benefit *and 8*: Awareness about the Indian Government's policies ti boost plant Breeding in India*/.*** Out of the 180

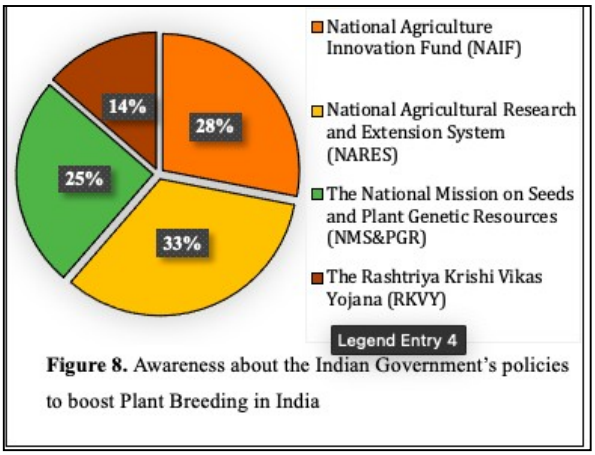

Figure 8. Awareness about the Indian Government's policies to boost Plant Breeding in India

farmers, *i.e.*, 60 each, interviewed from these three States of India, 97 farmers did not know about any of the aforementioned government schemes; 22 knew about the existence of the schemes, but not about the content; the rest, *i.e.,* only 61 farmers were found to be aware of the existence as well as the content of the schemes.

VII. Conclusion and Policy Recommendations

The agricultural sector has historically been the backbone of India's economy, providing livelihood to a substantial portion of the population. However, its share in rural employment has seen a sharp decline, dropping from 78.43% to 67.96% between 2020 and 2023. This downward trend raises concerns about the future of agriculture as a sustainable livelihood. A growing number of stakeholders appear to be losing faith in government interventions, leading to a deepening crisis in the sector. The grim reality is encapsulated in the words of a distressed farmer from Haryana: "इस देश का अन्नदाता आज खुद ही भुखमरी का शिकार हो रहा है" (Translation: The food provider of this country is himself becoming the victim of hunger).While India has an extensive legislative framework to support agriculture, the fundamental issue lies in poor implementation and accessibility. Policies such as PM-KISAN, PMFBY, and e-NAM have brought some relief, but their reach remains limited, especially among small and marginal farmers. The digital divide, bureaucratic inefficiencies, and lack of awareness continue to hinder their effectiveness. Bridging this gap is paramount to ensuring that governmental schemes truly benefit those who need them the most.

A critical step forward would be the decentralization of policy implementation by establishing district-level agricultural resource centers that offer direct assistance to farmers. These centers should focus on providing real-time grievance redressal, financial literacy training, and technological support for modern farming techniques. Additionally, quarterly workshops and awareness drives in remote areas should be conducted to educate farmers about subsidies, insurance claims, and sustainable practices. Furthermore, it is imperative to encourage eco-friendly farming solutions such as organic farming, crop diversification, and efficient irrigation systems. Expanding subsidies for climate-resilient farming, offering incentives for carbon sequestration initiatives, and improving rural credit access can help promote long-term agricultural sustainability. Digital platforms must be strengthened to ensure farmers can access weather forecasts, market prices, and direct government advisories without dependency on intermediaries. Unless India places its farmers at the center of its developmental agenda, the dream of becoming a truly developed nation will remain elusive. The prosperity of a nation begins with the prosperity of its food providers. Immediate, targeted, and practical efforts are required to bridge existing gaps and transform Indian agriculture into a resilient, sustainable, and inclusive sector.