

Review

A critical analysis of the policy potential for sustainable agriculture in India

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Abstract

Aligning the progress in terms of policy formulation in India with the changing climate is imperative for the evolution of agriculture towards a more sustainable and environment friendly sector, especially for an agro-dependent country like India with 17.6% contribution in GDP. As per last census conducted (in 2011), 54.6% of India's total population depends on agriculture as their primary livelihood. In this context, the current study emphasizes on ascertaining the major themes of the current policies being implemented in agriculture in India, while evaluating the potential of these policies in restructuring the agriculture into a more sustainable sector. The paper explores the different themes of the policies and the extent to which climate change and adaptation to climate change is discussed in the policies. The methodology includes a qualitative content analysis of the National level policies by using MAXQDA as the analysis tool. Policies largely focuses on increasing the cost-effectiveness and productivity of the agriculture and wants to increase the profitability from the economic sector with limited attention to farmer diversity and nuances of the socio-economic disparity. Tackling the disconnect between the policies and the nuances of the climate change reality of agriculture in India is imperative for comprehensive adaptation solutions and enhancing the sustainability of agriculture while addressing the increasing food security issues.

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Keywords Policy · Climate change adaptation · Sustainability · Content analysis

1 Introduction

Climate change represents one of humanity's most serious challenges in the twenty-first century. Changing climates particularly affect agriculture due to its direct dependence on climatic conditions. These changes can lead to reduced crop yields, altered growing seasons, and increased pressure from pests and diseases. Exacerbations in climate change disproportionately affects the agricultural productivity through erratic weather patterns, soil degradation, and water scarcity [18, 38]. The Intergovernmental Panel on Climate Change (IPCC) reports that for every degree Celsius increase in global temperatures, yields of staple crops like wheat, rice, and maize could decline by 6%, 3.2%, and 7.4%, respectively [28]. These reductions in crop productivity pose severe risks to food security, particularly in regions already suffering

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from food shortages [3]. The intertwined nature of agriculture and climate change necessitates comprehensive strategies that balance productivity with ecological stewardship. Sustainable agriculture has emerged as the solution in the global discourse in response to climate change and food security. As the world grapples with the dual challenges of environmental degradation and the need to ensure food for a growing population, agricultural systems are under increasing pressure to transition toward sustainability.

Sustainability in agriculture involves the adoption of practices that meet current food needs without compromising the ability of future generations to meet their own needs. The importance of sustainability in agriculture is underscored by the global commitment to the United Nations Sustainable Development Goals (SDGs), particularly Goal 2: Zero Hunger, which aims to end hunger, achieve food security, improve nutrition, and promote sustainable agriculture. This goal emphasizes responsible agricultural production and consumption to ensure that the nutritional needs of the estimated 9.6 billion population (by 2050) are met [57]. Achieving these targets requires a comprehensive understanding of how climate change affects agriculture and the development of strategies to mitigate and adapt to these impacts.

India, home to over 1.4 billion people and one of the world's most agrarian economies, provides a unique lens through which to explore the intersection of sustainable agriculture and climate adaptation. Despite its critical role in global food supply chains, India's agricultural sector is characterized by significant structural and policy challenges, including resource overexploitation, inequitable land distribution, and high levels of vulnerability to climate risks [43]. These issues underscore the urgency of re-evaluating and reforming agricultural policies to foster resilience and sustainability.

India's agricultural policies have evolved significantly since independence, primarily focusing on achieving food security and self-sufficiency. The Green Revolution of the 1960s and 1970s, marked by the introduction of high-yielding varieties (HYVs) of seeds, extensive use of chemical fertilizers and pesticides, and expansion of irrigation infrastructure, led to a dramatic increase in food grain production [59, 70]. However, these policies also contributed to environmental degradation, including soil health deterioration, groundwater depletion, and increased greenhouse gas emissions, and created economic dependencies on fertilizer, seed material and land ownership, to name some of the examples of the effects of globalisation.

But, recently, policy efforts have shifted towards addressing the environmental impacts of intensive agriculture while continuing to support productivity and income growth for farmers. The Indian government has recognized the need to integrate climate resilience into agricultural policies. The National Action Plan on Climate Change (NAPCC), launched in 2008, outlines India's strategy to address climate change through eight national missions [41]. Programs such as the National Food Security Mission (NFSM) and the Rashtriya Krishi Vikas Yojana (RKVY) (launched in 2016) have aimed to promote balanced fertilizer use, efficient water management, and integrated pest management practices [21].

However, a critical gap exists in understanding how India's agricultural policies align with its climate commitments and broader sustainability goals. While the importance of sustainable agricultural practices has been widely recognized, the focus has often been on macro-level analyses or isolated case studies. Recent literature, such as the works of [17, 79] has highlighted the need for region-specific evaluations that integrate socio-economic and environmental dimensions. Existing research has either been limited in scope or has failed to account for the dynamic interplay of institutional frameworks, economic incentives, and local realities. Key components include the development of climate-resilient crop varieties, soil health management, efficient water use, and the promotion of agroforestry and organic farming. Despite these initiatives, the existing policy framework often falls short of addressing the complex and multifaceted challenges posed by climate change.

The themes of agricultural policies shape how food is produced, how resources can be managed to the best, better livelihood provisions for rural economies, and ensure sustainable development of the agriculture sector [20]. Analyzing themes in agricultural policies is essential for understanding their effectiveness in addressing complex, interconnected challenges such as food security, climate change, and rural poverty. Policy analysis allows for the identification of strengths, gaps, and unintended consequences, helping to improve policy design and implementation [64]. By examining themes like sustainability and economic resilience, analysts can assess how well policies align with ecological principles and market demands, supporting more adaptive and long-term solutions [5–7, 55]. Additionally, analyzing these themes aids in the evaluation of social equity impacts, particularly for smallholder farmers and vulnerable populations who may be disproportionately affected by policy shifts [71].

Given the current scenario, climate change and its adaptation become an imperative aspect to be focussed in policies. It is suggested that the policies should focus on rainwater harvesting and the development of robust water storage infrastructure to mitigate the impacts of monsoon variability and seasonal droughts to ensure a reliable water supply for irrigation, thus preparing farmers for better adaptation [49, 63]. Developing and disseminating crop varieties that can withstand heat, drought, and flooding, encouraging crop diversification and integrated farming systems can reduce

the risk associated with climate variability and improve their adaptability [76, 78]. Policies focused on strengthening extension services to disseminate knowledge about climate-smart agricultural practices can empower farmers to adapt to climate change effectively [1].

This precarious situation demands a comprehensive review and revision of existing agricultural policies to ensure they are robust enough to address emerging climate-related challenges and promote sustainable agricultural practices. In countries like India, where agriculture is a crucial component of the economy and the primary source of livelihood for a large segment of the population, the impacts of climate change are particularly profound [22]. The interplay between climate change and agricultural policies is therefore critical in shaping the future of India's agricultural sector. Current policies must be aligned with the goals of enhancing climate change adaptation and sustainability to protect the livelihoods of millions of farmers and ensure long-term food security. By integrating climate adaptation and sustainability into the policy framework, India can better equip its agricultural sector to cope with the adverse effects of climate change. This approach will not only safeguard food security and farmer livelihoods but also contribute to the broader goals of environmental sustainability and economic stability [6].

Therefore, the present study is intended to assess the current state of policy affairs in Indian agriculture, their role in making agriculture more climate-adaptable, enhancing its sustainability, and eliminating concerns hindering the growth of agriculture in India. Building on seminal contributions in ecological economics and sustainable policy frameworks [25, 68, 79] and recent advancements in understanding the socio-economic impacts of climate-adaptive strategies, this paper seeks to provide a holistic perspective. This study contributes to the evolving literature on sustainable agricultural transformations in the Global South.

2 Methodology

Our analysis of national-level policies was aimed at coding and analysing the policy documents that focus on agriculture policies on a national level and are compiled in English by performing a 'qualitative content analysis' [39] (Table 1). The analysis focussed on Indian agricultural policies on climate change and sustainability in agriculture. The analysis was used to identify specific parts of the policy texts that discuss agriculture and shape the practices being implemented in agriculture. The framework used in the study addresses the determinants of transformation towards sustainable agriculture. All factors creating an impact on farmers such as financial support, educational support, assets and endowments, and production-oriented support were analysed. The policies were coded based on predefined categories such as climate change, relationships with other policies, the definition of farmers, monitoring of policies, and bodies governing the implementation of policies, in addition to the topics mentioned in the initial framework.

2.1 Policy search and collection

For the past few years, transformation in agriculture has been widely discussed in various capacities in India, with a dedicated focus on climate change and its adaptation. Various policies have incorporated climate change mitigation, and its impacts (NMSA; NBM, PMFBY). All the policies aiming at the improvement of agriculture, whether be it by reforming market availability or reducing production risk, or increasing yield, were compiled, and considered for this analysis (see online appendix). All documents not available in English language or electronic form were excluded (Fig. 1). Hence a total of 49 policy documents and mission guidelines were downloaded for content analysis at the national level. Out of these policies, after first screening 31 significant policies were selected for the final analysis (see Supplementary data). All the policies were available on open-source website maintained by the Government of India (<https://agricoopgov.org>).

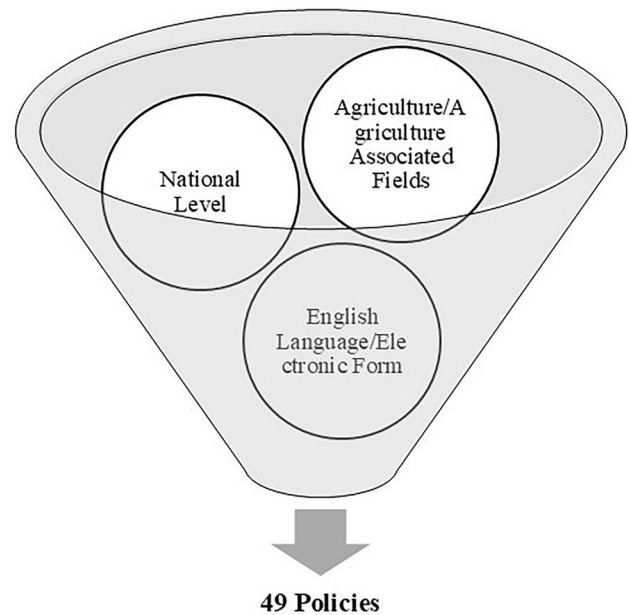
2.2 Qualitative content analysis (QCA)

Qualitative content analysis aims to determine the presence of certain phrases, concepts, or themes in a text, allowing the researcher to evaluate the information contained in a policy document by rendering the language used by policymakers [10, 24, 39]. QCA of policy documents was conducted using a deductive as well as inductive approach to structure the content. Based on aspects stemming from the literature, a category system to code the material was developed (Table 1). We used MAXQDA (version 22) to conduct the content analysis, focussing on examining the incidence and treatment of current issues faced by agricultural communities in India (Fig. 2). The coded text was read and interpreted manually after obtaining the word frequencies from the text search.

Table 1 Following framework was used to code the policies

Level	Category	Diversity dimension	Coding scheme (text search query)	
Individual	Financial	Loans	Various types of loans, mention of loan, increase or decrease in loan amount, changes in documents required for loan, considers crop loss by natural disasters	
		Credit	Money provided on credit, considers crop loss by natural disasters, credit value increased or decreased over time, credit value varies from climate sensitive zones to least impacted zones	
Community	Educational	Banks/banking	Considers crop loss or land quality impacted by natural disasters, monetary assistance, interest rates	
		Scholarships/Vocational training	Agricultural training, courses about advanced techniques, teaching adaptation methods	
	Assets and endowments	Agencies/educational centers	Such as various NGOs, governmental organizations	
		Land owned	Subsidy in land prices, ownership benefits, quality of soil	
	Production orientation	Irrigation	Change in rules/regulations regarding irrigation facilities, help provided for irrigation purposes, and, establishing and maintaining irrigation sources	
		Livestock holding	Any support for livestock rearing and bearing	
	Subsistence	Market oriented	Livelihood diversification	Diversifying income sources, help in handloom or mini-industries setup
			Accessability to market, maximum selling price regulation	Types of food crops, support for traditional methods or conventional methods
		Seeds	Subsidy on the seed prices, seed banks, help for seed conservation	
		Fertilizers	Subsidy on fertilizers, changes in fertilizers quality or quantity, organic farming	

Fig. 1 Diagram showing the policy selection criteria for our current study



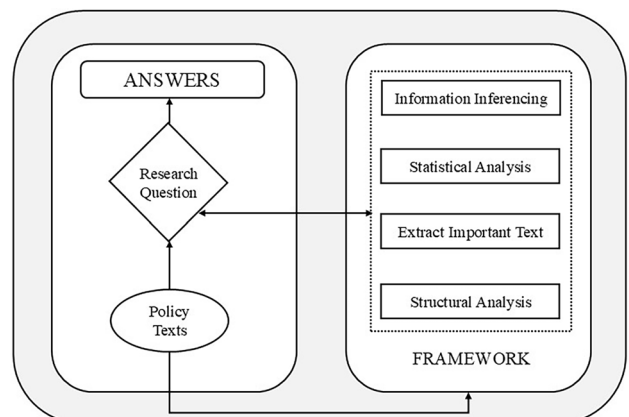
We analysed the texts and passages that included the terms related to 'climate change', 'sustainability in agriculture', and 'climate adaptation' within the documents. We sought to examine how government policies evolve through the lens of a climate change-related policy paradigm, focusing on policy problems, objectives, and tools [4, 77]. By analysing the textual corpus as a product of expansive policymaking practices [26], we aim to interpret the findings within a broader sustainability context, exploring the climate understanding and knowledge frameworks that inform the creation of these policies.

3 Results

3.1 Key themes of the policies

The policies hardly define the small and marginal farmers as families those owning cultivable land up to 2 ha. Land endowment is only discussed in 2 of the total 41 policies, defined in none. Defining helps in specific targeting of these families highlighting the focus on supporting the most vulnerable agricultural stakeholders. Despite huge 'feminization of agriculture' (defined by Pattnaik and Lahiri-Dutt [51] as women's increased responsibilities in agriculture) in India, only 13 documents out of the total 31 documents talk about gender-based differences among farmers. Even then, most often the discussion is combined with the caste or culture of the community. Another major theme was 'dissemination

Fig. 2 Diagrammatic representation of steps involved in content analysis



of information' or 'educational/vocational training'. Opening centres providing information and knowledge to farmers regarding seed quality, better mechanization and irrigation technologies, seemed few of the priority agendas in these policies.

The main target of most policies is to improve farm productivity, enhance agricultural research, and support the most vulnerable agricultural stakeholders. This is achieved by having policies which focus to improve soil health to increase yield production (discussed in 25% of policies), fertilizer subsidy or support (discussed in 20% of policies), as well as improving infrastructure and seed quality. The policies (29%) discuss integrated approach towards agricultural development to ensure a comprehensive approach to agricultural productivity. Almost 87% of the policies focus on enhancing productivity of the agricultural yield, highlighting the 'production oriented' attitude of Indian policy makers.

Many policies discuss providing financial and technical assistance to the farmers as their key theme. Almost 24% of the policies talk about providing financial assistance in the form of loans or direct credit. The policies also talk about machinery banks which supports farmers in buying agricultural related machinery. Policies such as AMI, ATMA, NFSM have a detailed funding mechanisms and the provision of technical training for extension officers and scientists. They also have required vocational training programs for farmers, thus underlining the commitment to capacity building and resource allocation. More than half (58%) of the policies have infrastructure development as their key theme. Initiatives like the development of high yield seed quality, rural haats*, Mandi's (local sellers' markets), and micro-irrigation systems aim to build robust agricultural infrastructure at the grassroots level.

A data-driven approach was also noticed in policy making. Agricultural census data was collected and utilized in better formulation and evaluation of the implemented policies. The analysed documents also outline extensive collaboration between national, state, and local bodies, as well as international organizations, indicating a multi-level governance model. Regular monitoring by agencies like NABARD and state-level committees ensures accountability and effectiveness in the implementation of various schemes.

3.2 Attitude towards climate change and adaptation provisions

The content analysis showed a rather sad attitude towards discussing climate change and associated adaptation provisions. Total of 8 policies fall under the umbrella of climate change, but no one defines climate change. The policies do discuss the adaptation and mitigation measures in the text. From the other agricultural policies at national level, climate change and related concerns are absent. Only one policy, NMSA discusses the importance of implementing sustainable agricultural practices as an important step in adapting towards changing climate. Table 2 gives the list of policies and their adaptation initiatives.

The table shows a clear picture of most policy initiatives aiming at reducing the production risk due to erratic rainfall or decrease in arable area. A great emphasis is laid on managing irrigation sources or providing financial aid to farmers suffering loss during harvest. The technical solutions for risk management such as better variety of seeds, heat tolerant varieties, micro-irrigation systems, crop insurance etc. are also mentioned and often seem to be the primary response of the policies. Considering the need to mitigate social risks, short-term interventions such as livelihood diversification, sustainable tourism are also mentioned, but not to great extent. Despite technical risk management approaches being successful, their uptake depends largely on the socio-economic status of the farmers, making them non-equitable resolutions for all farmers [14, 42, 52]. Therefore, viewing them as "one-size fits all" would be a mistake on the part of the policy formulators.

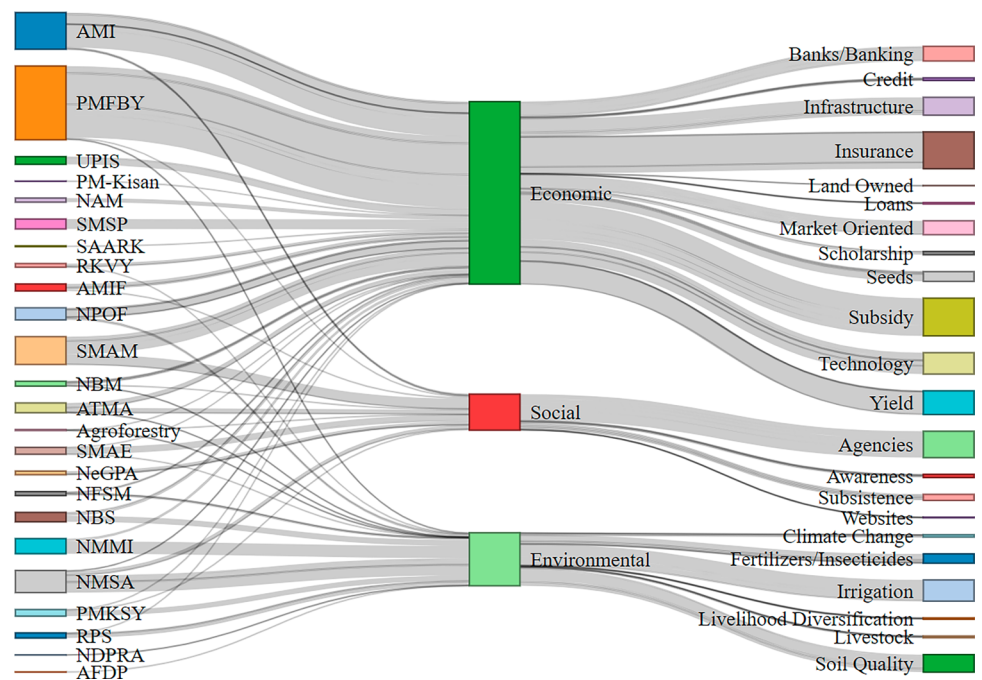
Table 2 Adaptation provisions mentioned in the policies

Adaptation provisions in policies	Policy	Discuss subsistence farming	Anyone/no mention
Improved crop seed variety/livestock and fish cultures	NMSA, RKVY, ATMA, NDPRA, SAARK	+	+++
Better technology, mechanization, infrastructure	RKVY, ATMA, NAP, NMAET, SMSP	+++	++
Soil quality improvement and nutrient management	RPS, NABARD,	+	+++
Water use efficiency	NMSA, RKVY	+++	+
Research and education, skill development	SMSP, SAME	++	+++
Increasing forest cover	RPS, agroforestry (RKVY)	-	+++

Table 3 Codes distribution (deductive) into three dimensions of sustainability

Environmental	Economic	Social
CC	Banks	Awareness
Fertilizer	Credit	Website
Livelihood	Infrastructure	Agencies
Livestock	Insurance	Subsistence
Irrigation	Land owned	
Soil quality	Loans	
	Market	
	Scholarship	
	Seeds	
	Technology	
	Subsidy	
	Yield	

Fig. 3 A sankey plot showing the flow and strength of connections from policies (right hand side) to codes (left hand side) through the three sustainability dimensions (center)



Furthermore, technical resolutions contribute to the current dominance of ‘lab to land’ nature of adaptation provisions, which fail to factor in the specific needs and individual veracities of farmers [12]. Although, NMSA document does acknowledge the importance of an holistic approach and the role of “Involving knowledge institutions and professionals in developing climate change adaptation and mitigation strategies for specific agro-climatic situations and promoting them through appropriate farming systems” and lays priority on understanding micro-climate for better strategy development, but there seems to be lack of provisions bridging the gap between imminent climate threats and future impacts of the same.

3.3 Policies and sustainability elements

The agricultural ministry of India has realized this necessity which can be seen in the recently formulated policies with emphasis on enhancing sustainability of agriculture. To further understand the contribution of each policy into sustainability, we tried to break (deductively) the codes into dimensions of sustainability. This will help us in identifying the sustainability dimension lacking behind. We divided the codes into Environmental, Economic and Social dimensions of sustainability (Table 3). Then we tried to plot the movement of relations among the policies, codes and dimensions (Fig. 3).

Economic dimension contributes the most (almost 53% by frequency of codes discussing sustainability), followed by environmental (29%) and social (only 18%). A huge amount of attention is given to providing communities with subsidies and insurance, this highlights the poor economic state of Indian farmers. Technology adoption is another tool mentioned in policies alongside yield. Significance of farming technological innovations in making agriculture more sustainable has been considered a huge contributor but its adoption is often dependent upon the wealth farmers' family hold [45, 50]. The policy analysis provides no evidence that the above has been considered during policy formulation. But one can say that considering technology as a solution, is a big step by Indian policy makers.

4 Discussion

In recent years, policy analysis has taken an argumentative turn, most of which use a heuristic approach, encouraging the critique of policies and thus, pave the road towards improving them [75]. Such type of policy analysis has proved themselves useful in development of a just and sustainable world, consistently providing vital insights into the issues and problems between the policy formulation and implementation [16, 19, 36]. Our study suggests changes or reforms to established policies for enhancing agricultural productivity, food security and diversify livelihood while simultaneously make it more sustainable.

Regardless of the efforts made by the authorities, there still seems to be missing pieces crucial for adaptation of agriculture and associated communities to climate change. One such piece is farm and family size. None of the policies discuss these within the text. Especially in the India, average farm size positively co-related with income levels [58]. During the last few decades, the share of farm size has decreased from >5 to <1 ha, which shows an increase in smallholder farmers. The fragmented nature of landholdings, with a significant proportion of farmers operating small and marginal farms [44, 66] leads to a lack of resources and access to technology. Farm size determines the agricultural outlook of farmers and enables better adaptation towards climatic stressors [3, 9, 31]. The family size has been a well-established factor in helping farmers cope with the changing climate and its stressors [8, 74]. The above-mentioned discoveries reveal that limited attention is given to individual farm household needs within policy domain. There seems to be a lack of significance given to understanding diversity among the farming community which are identified to be critical for Indian farmers. These farmers often lack the resources.

One reason of the low abundance of climate change within policy documents can be rooted to huge disparity in socio-economic status of agricultural communities in India. Socio-economic disparity has been a continuous challenge in India and thus created an almost singular focus for policymakers [56]. The fact that increasing climate change contributes to enhancing these disparities by making the communities differentially vulnerable is often overshadowed and underrepresented in the policies [65, 72]. This aligns with the results of our analysis where most of the policies are focussed on providing financial support to farmers, and on setting up social service agencies (Fig. 1). Subsidy, insurance, irrigation, infrastructure are some of the major concerns tackled in our current policies, which gives us a picture of the existing socio-economic state of agricultural community.

Even the codes representing the environmental dimension of sustainability aligns with the idea of overall development by improving economic state (enhanced productivity, increased livelihood, better yield and infrastructure etc.) of agriculture and associated communities. This also proves that there is a growing consensus among the key stakeholders of Indian agriculture, along with the government, policy makers and industry, of utilising a diverse range of fertilizers (chemical, organic, bio-fertilizers) for heightening the agricultural productivity. However, numerous studies have suggested that excessive fertilizer use has led to a decrease in soil quality (and in turn longevity of farmland), increased release of ammonia into atmosphere etc. [13, 32, 46].

Our analysis also points out that awareness is among the least discussed despite numerous studies proving that access to education can prepare agricultural communities with knowledge and information about modern farming approaches, mechanization, enhanced adaptation capabilities, and thus in turn better equipped towards climate change. Education also makes the communities aware about the sustainable methods of farming, e.g., organic farming, environmentally friendly pest control, soil testing etc. and increases the chances of their adoption [48, 67]. The current global environmental situation, and its impacts on Indian sub-continent, has put agriculture in India at a critical crossroad, demanding tactical planning to transform the agriculture while concurrently upholding the required food security and ensuring sustainability for the future [11, 30, 53, 76].

Unlike earlier studies, which often focused on isolated factors like financial access or agricultural yield, [35, 61] this analysis adopts a holistic approach, integrating diverse domains such as climate change, financial structures, educational

efforts, and production orientation [7]. The present study expands its scope to include technological adoptions, infrastructure improvements, and capacity-building initiatives. The current study highlights a more nuanced understanding of adaptation provisions, tailored to specific farming contexts, such as subsistence farming versus market-oriented approaches. This differentiation marks a departure from earlier studies that typically applied one-size-fits-all strategies. The findings underscore the significance of diversified livelihood strategies, infrastructure advancements, and educational outreach, which were often underrepresented in prior analyses [47, 57]. Notably, the comparative analysis of policy effectiveness, ranging from soil quality management to skill development programs, aligns with emerging research advocating for multifaceted and adaptive policy frameworks. Such an inclusive and detailed approach offers a more actionable roadmap for policymakers, ensuring that interventions cater to varied agricultural and socio-economic contexts.

4.1 The role of farmers in sustainable agriculture

In the past years, administrative interventions for agriculture have strengthened, and can be further improved. One of the most effective ways to make Indian agriculture more sustainable is by promoting sustainable farming practices. Farmers are at the forefront of sustainable agriculture as they are the primary managers and decision makers with regards to agricultural lands and resources. Their actions and decisions significantly influence the sustainability of agricultural systems, making their role critical in achieving the goals of sustainable agriculture [73]. Farmers can have a huge contribution to sustainable agriculture by adopting various practices that reduce environmental impacts and enhance the resilience of agricultural systems [55]. One example is implementing crop rotation and diversification which helps in maintaining soil fertility, reducing pest pressures, and increases biodiversity on farms [37]. Another example is, conservation tillage practices, which includes minimal soil disturbance, maintaining soil cover, reduces soil erosion, and conserve water, and enhance soil organic matter, contributing to better soil health and carbon sequestration [29, 34].

Farmers are also responsible for making decisions regarding resource managements in fields, such as water distribution, fertilizers use, and mechanization. Making farmers more aware and trained in better techniques, such as drip irrigation, organic farming, rainwater harvesting, efficient machinery use, reducing waste can prove to be a vital component of sustainable agriculture. These practices are essential in many parts of India where water scarcity is a significant concern, fertilizer use is being exploited, and old-school tools are still being used [23, 40]. With increasing concerns about habitat and biodiversity loss, and a huge land being used in agriculture, we can enhance on-farm biodiversity by maintaining natural habitats, such as riparian buffers and hedgerows and support ecosystem services alongside getting the added benefits of integrated pest management [33].

The above section shows that how most of the decisions and possible changes in agriculture to make it more sustainable rely on farmers and their families. Despite their critical role, farmers face several challenges in implementing sustainable practices. Economic constraints, lack of access to knowledge and resources, and market barriers can hinder the adoption of sustainable farming methods [54]. To overcome these challenges, there is a need for supportive policies, financial incentives, and education programs that promote sustainable practices. Engaging farmers in participatory research and extension services can also empower them to innovate and adapt sustainable practices to their local conditions, thereby enhancing the sustainability of agricultural systems globally [2, 15]. Effective and updated framing and implementation of policies is a major component for constructing the way and determining indisputable progress within the agriculture domain and in making it sustainable [57].

5 Conclusion

In an agrarian country like India, where farmers are the main end-decisions makers, making agriculture sustainable at a national level, during the entire process of crop production, from farm to feed, is a difficult task. Yet we want to highlight this step as crucial in current times where the vulnerability of farming communities is increasing with changing climate. The present analysis tried to understand which changes into the policies will make the transition smooth and fast, as well as align the interests of farmers. The results indicated that 'social factors' should be more included within policy initiatives, as social factors have the capacities to tackle the vast diversity present in Indian agrarian scene [62, 69]. Our study also indicated that farmers should have 'access to' food grains, rather than focusing the target on 'production of' food grains. Heterogeneity among the farming community is often overlooked which hinders the smooth implementation of current policies. This makes one to question the inclusivity of the existing precatory measures being applied while consider equal distribution of resources via subsidy policies [60].

Finally, our policy content analysis also determines that the existing policy framework needs an immediate change for timely success of sustainable agriculture. Agriculture and Farmers Welfare (A&FW) is India's ministry which is dedicated to the cause of agriculture and is responsible for formulation of numerous missions and policies. This decisively indicates that agriculture is a key concern for Indian Government. But our policy analysis notices a lack of concern and growth towards sustainability of agriculture. Missions focussing on some of the concerns regarding providing farmers with the autonomy and authority to make agriculture sustainable have been drafted in recent years (SMAM in 2014–15, NMSA in 2014, RKVY-AGRICoop, 2014 etc.). A detailed list of policies and their roles can be found in supplementary datasheet. We need to implement 'Integrated Farming System' and formulate policies that consider these.

The following points should be considered by policy makers while trying to incorporate sustainability and climate change in current policies:

1. Strengthen multi-stakeholder collaboration for financial inclusion and technological dissemination.
2. Expand educational outreach and vocational training tailored to climate-resilient agriculture and the needs of local communities.
3. Enhance the monitoring and evaluation frameworks for policy implementation effectiveness.
4. Increasing the integration of digital tools like websites/applications to improve access to policy benefits and resources is required.

However, the effectiveness of these interventions hinges on addressing the implementation challenges and exploring the role of finances in supporting sustainable agriculture and providing educational measures. Future strategies must incorporate digital tools, such as climate-resilient technologies to enhance farmers' adaptation capacities and resilience [27].

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Declarations

Ethics statement and informed consent Not applicable.

Consent to publish Not applicable.

Competing interests The authors declare no competing interests.

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