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# Challenges for crop diversification in cotton-based farming systems in India: a comprehensive gap analysis between practices and policies

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**Introduction:** Crop diversification is a promising practice to improve the sustainability of agricultural production systems, contributing to biodiversity conservation, ecosystem functions, and food security without compromising productivity. Although diverse cropping systems may be more labour-intensive and require good knowledge of the specific cropping system in the local context, they have high potential in managing many of the problems faced in current cotton production in India. However, the adoption of crop diversification is still moderate, with an overall crop diversification index (CDI) of 0.65 for all of India and state-wise CDI between 0.43 and 0.83.

**Methods:** Therefore, a four-phased study was conducted to identify the main barriers to crop diversification in cotton-based farming systems in India and highlight levers that can foster their wide adoption to improve the livelihoods of smallholder farmers. The study was carried out between January to October 2020 and consisted of i) a literature review of regional and national policy and planning, ii) situational analysis with a problem tree approach, iii) individual stakeholder interviews with stakeholders from the broader Indian cotton sector, and iv) a participatory feedback workshop with said stakeholders. A total of 51 stakeholders from 24 different organizations were interviewed, 37 of them on technical aspects of crop diversification and 21 stakeholders on market and policy aspects. The same stakeholders were invited to the participatory feedback workshop, where 26 participated in the session on different benefits of crop diversification practices, and the session on market and policy challenges counted 24 participants. The study focused on the main organic cotton producing states in India: Gujarat, Madhya Pradesh, Maharashtra, Haryana, Odisha, and Andhra Pradesh.

**Results and discussion:** In our study, it became evident that many policies and governmental schemes exist to promote national food security, sustainable agriculture, and agricultural marketing infrastructure, but crop diversification is still not gaining momentum on the ground. Various levers were identified in the

areas of market and procurement, capacity building and knowledge transfer, supply industry and infrastructure, and farmers and women empowerment, where the current policy landscape is failing to foster crop diversification effectively on the farm level.

KEYWORDS

barriers and levers, crop rotation, intercropping, organic cotton, situational analysis, smallholder farmers, sustainable agriculture

# 1 Introduction

Cotton is an indispensable commodity, accounting for 81% of natural fibres produced globally (FAO, 2021), with production of over 24 million tons in 2021 (Textile Exchange, 2022). The cotton sector is a key driver for many developing countries' economies and provides employment and livelihoods to millions of rural smallholders. India is one of the two largest cotton-producing countries worldwide, with a share of 21.5% (seed cotton production 2022: 15.0 million t), closely following up after China with a share of 26.0% (18.1 million ton) (FAO, 2023). In terms of area harvested, India is the world leader with 12.4 million ha (39.4% of total cotton area worldwide) (FAO, 2023).

In India, the cotton sector is providing employment and livelihoods for an estimated 5.8 million farmers and up to 50 million people engaged in the broader cotton industry (Government of India, 2023b). However, India's smallholder cotton farmers faced many adversities in the past two decades, with stagnating yields, high pest infestation pressure and increased dependency on cost-intensive inputs (such as hybrid seeds, pesticides, and fertilizer) connected to the introduction of input-intensive hybrids (Kranthi and Stone, 2020). Extensive use of external nutrient and plant protection measures not only poses a financial burden to farmers, but pesticide exposure also affects their health and poses a greater environmental risk. Moreover, cropping and production systems focusing on one main cash crop also make the farmers dependent on input providers and vulnerable to market volatilities and crop failures due to unfavourable or extreme weather conditions (which are becoming more frequent/severe due to climate change (IPCC, 2023)). Intensive production of few major cash crops also leads to overexploitation of natural resources, as an example shown in the northern states of Haryana, Punjab, and Western Uttar Pradesh, where decades of intensive paddy and wheat production severely depleted the groundwater reserves of the region and deteriorated soil health (Government of India, 2013).

Crop diversification is a central concept in sustainable agricultural practices and refers to the maintenance of "multiple sources of production" by varying the crops grown in temporal (e.g. crop rotation, multiple cropping) and spatial (e.g. intercropping, mixed cropping) scale (IPES-Food, 2016). Even though it can be applied at different spatial levels (Hufnagel et al., 2020), we are referring to crop diversification at field and farm level, and not at landscape level. Crop diversification practices have high potential in managing many of the problems faced in current cotton production in India, to improve cotton yield and sustainability of the production system and improve smallholder farmers' livelihoods. Many studies have shown that crop diversification can support biodiversity, ecosystem functions, and food security and alleviate the negative effects of continued monocropping (Kremen and Miles, 2012; Brooker et al., 2015; Beillouin et al., 2019; Renard and Tilman, 2019; Tamburini et al., 2020). It is an integral component of organic farming systems: As synthetic pesticides and fertilizers are prohibited in organic farming, crop rotations, intercropping, and the strategic use of green manure and border crops are central strategies to manage pests and diseases and meet the nutrient requirements of the crops. Although diverse cropping systems may be more labour-intensive and require good knowledge of the specific cropping system in the local context (Iles and Marsh, 2012; Rodriguez et al., 2021), they can reduce costs for inputs, decrease farmers' dependency on input providers and contribute to household food security of smallholder farmers (Bacon et al., 2012; Njeru, 2013; Armengot et al., 2016; Makate et al., 2016; Sánchez et al., 2022). By introducing legumes, minor cereals, and millets into the cropping system alongside cotton, farmers can not only enhance soil fertility through nitrogen fixation by legumes but also bolster agrobiodiversity (Rochester et al., 2001; Kremen and Miles, 2012). The inclusion of diverse crops not only mitigates pest pressures but also fosters a resilient ecosystem, reducing the reliance on chemical inputs (Kremen and Miles, 2012; Degani et al., 2019; Tamburini et al., 2020; Jaworski et al., 2023). Moreover, diversifying diets by incorporating nutritious crops like legumes and millets can address malnutrition and contribute to food security, thereby enhancing the overall well-being of farming communities (Makate et al., 2016; Adjimoti and Kwadzo, 2018). This holistic approach to crop diversification aligns with sustainable agricultural practices, promoting ecological resilience while safeguarding the livelihoods of smallholder farmers.

Despite all its benefits, overall adoption of crop diversification is moderate, with a crop diversification index (CDI) of 0.65 for all India, ranging from a CDI of 0.43 for Goa, to 0.83 in Gujarat (Kumar et al., 2023). Recent studies reported similar patterns in European countries and identified the main barriers for the adoption of crop diversification to be limited technical knowledge of farmers, lack of suitable resources (such as equipment, crop

varieties) and markets for minor crops, and the policy environment failing to incentivize crop diversification (Morel et al., 2020; Rodriguez et al., 2021; Di Bene et al., 2022).

Furthermore, in India, a plethora of policies and initiatives are in place to directly and indirectly promote crop diversification, as evidenced by an array of governmental schemes and missions targeting various aspects of agricultural development (among others, under the National Programme for Organic Production (NPOP) and the National Mission for Sustainable Agriculture (NMSA)). However, a notable disjunction persists between policy objectives and on-ground practices. While policies underscore the importance of diversification, prevailing agricultural practices often prioritize monocropping, particularly in sectors such as cotton farming, due to concerns over market stability. This discrepancy exposes farmers to market volatility and restricts their access to premium prices for diversified crops. Despite efforts to address soil fertility and agrobiodiversity through policy measures, practical implementation remains inadequate, leading to sustainability challenges and ecological imbalances. Furthermore, policies tend to prioritize economic gains over holistic farming approaches, sidelining the role of diversification in enhancing farmer resilience.

In this study, we aimed to identify the main barriers for crop diversification in organic cotton-based farming systems in India through a gap analysis between existing policies and on-ground practices and highlight levers that can foster the wider adoption of crop diversification practices and maximize the potential of such practices for actual income generation and improved livelihoods of smallholder farmers.

# 2 Methods

## 2.1 Governance structure of cotton in India

India has a system of Minimum Support Prices (MSP) paid by public procurement agencies for 23 commodities, including cotton. The MSP are set and announced by the Government of India every year and guarantee a minimum price the farmers get for selling their produce to the procurement agencies. The MSP considers factors such as production costs and living costs and aims at allowing a farmer a margin of at least 50%. The MSP system intends to provide price security to farmers, however, challenges remain in the implementation of the MSP system on-ground (Aditya et al., 2017). For organically produced crops, there is no such public system. Organic cotton farmers can join organic cotton farmer associations who will pay a premium price for the organic cotton. However, there is no purchase guarantee, and in case organic standards are not met, farmers have to sell their produce in the conventional market, putting them at greater risk.

## 2.2 Study area and period

The study was carried out between January and October 2020. A four-phased study was planned; i) a literature review of regional and national policy and planning, ii) situational analysis with a problem tree approach, iii) individual stakeholder interviews with stakeholders from the broader cotton sector in India and iv) a participatory feedback workshop with said stakeholders. This participatory approach was chosen to ensure that on-the-ground expertise is reflected in the findings and that the outcomes of this study have practical relevance to the Indian organic cotton sector. The study focused on the main organic cotton producing states in India – Gujarat, Madhya Pradesh and Maharashtra in Central India, Haryana in Northern India, Odisha in Eastern India and Andhra Pradesh in Southern India (Supplementary Figure S1).

## 2.3 Literature review

The reviewed literature included relevant scientific literature on Indian cotton production, government and state publications such as policy documents, recommendations, reports and statistics from the Ministry of Agriculture & Farmers Welfare, the Department of Agriculture & Cooperation, the Directorate of Cotton Development, the Ministry of Commerce & Industry, the Directorate of Economics and Statistics (DACNET) and the agricultural extension centres Krishi Vigyan Kendra (KVK); data, reports, recommendations and documents from the Central Institute for Cotton Research (CICR), FAO, Small Farmers' Agri-Business Consortium (SFAC), Package of Practices from Agricultural Universities, the Indian Council of Agricultural Research (ICAR). The focus was to understand the policy framework and recommendations from official governmental and public institutions that promote or enable diversified cotton production practices directly or indirectly, as well as gathering evidence of on-ground adoption of diversification practices in cotton production systems. A detailed list of reviewed policy documents can be found in the Supplementary Materials (Table S1).

## 2.4 Situational gap analysis

A situational analysis was conducted to identify the root causes and effects of poor diversification of organic cotton-based farming systems in India. The problem tree approach (ODI, 2009) was used to map the interconnectedness of these effects and causes. The resulting problem tree was complemented with inputs received during the stakeholder interviews and relevant literature and validated by the stakeholders during the participatory feedback workshop. After the workshop, the findings on current agricultural practices from the stakeholder interviews and participatory feedback workshop were compared against existing policy approaches gathered during the literature review to identify gaps, highlighting discrepancies between policy intent and stakeholder revelations in order to support a comprehensive understanding of the policy landscape and its implications for agricultural practices.

## 2.5 Stakeholder interviews

One-on-one semi-structured phone interviews were conducted with a total of 51 stakeholders from the Indian organic and broader

cotton sector from 24 different organizations, including the State Agriculture Department, State Agricultural Universities, central research institutions dedicated to cotton research and other crops, agricultural extension centres (KVK), seed producers, NGOs, and other actors engaged directly or indirectly in the organic cotton sector. These stakeholders were researchers, scientists, agricultural academicians, extensionists, market experts, and representatives of organic farm groups. Their expertise referred to the main cotton-producing states (Central India: Gujarat, Madhya Pradesh, Maharashtra; Northern India: Haryana; Eastern India: Odisha; Southern India: Andhra Pradesh) as well as Pan India (Supplementary Figure S2). The distribution of experts reflects the distribution of the main production areas for organic cotton.

The stakeholder interviews aimed at gaining a better understanding of the current levels of crop diversification, including characterization of farmers and the connection of the stakeholders to the farmers, the prevalent region-specific types of cotton-based farming systems, awareness of policies supporting crop diversification, challenges related to marketing of diversified produce and strategies for the promotion of diversification practices amongst farmers. In total, 37 stakeholders were interviewed on the technical aspects of crop diversification ("technical interview"), and another 15 interviews with 21 stakeholders focused on the set-up of marketing linkages and policy considerations for diversified produce ("market interview"). In three cases, two to five persons were interviewed together, and their responses were compiled. The question forms for both the technical and market-related interviews contained a mix of open-ended questions and questions with pre-defined answer options (Supplementary Material S1, S2). Answers to the different questions were then compiled and grouped state-wise and/or into topical groups to be able to assess the breadth of answers and most common responses.

## 2.6 Participatory feedback workshop with stakeholders

After evaluation of the literature review and stakeholder interviews, the comprehensive inputs were validated during two online participatory feedback workshops where the same stakeholders were invited to participate. One session focused on the agronomic, economic and environmental benefits of crop diversification practices (26 participants). The second session with 24 participants put the focus on market and policy challenges as well as opportunities for the expansion of adoption of crop diversification practices in organic cotton farming systems. Focus group discussions during both feedback workshops ensured high levels of active involvement and participation of the stakeholders. Emphasis was put on the in-depth validation of the findings of the stakeholder interviews. Each focus group fully endorsed the findings, with only few participants coming up with minor suggestions and recommendations.

# 3 Results and discussion

## 3.1 Current adoption of crop diversification practices

Over 70% of cotton farmers in India are smallholder farmers with land holdings of under 2 ha (Government of India, 2020a), depending strongly on cash crops for income generation, as these offer relatively stable markets and profitable prices. Studies from different areas in India showed that diversified cotton production systems can surpass cotton monocropping systems in profitability (Sepat et al., 2012; Raju and Thakare, 2013; Singh et al., 2014; Saravanakumar, 2022) and can thus be an interesting practice for farmers to not only diversify risks but also increase profitability. In the case of cotton, organic farmers may profit from a higher premium price paid for their organic cotton when sold to farmer associations for organic cotton. Such premium prices range from 5% to 20% above market price for conventional cotton (Voora et al., 2023). And although crop diversification is a requirement for organic cotton production "where appropriate," according to the Indian National Programme of Organic Production (Government of India, 2014), the level of crop diversification in cotton-based cropping systems is still low, as stated by the stakeholders interviewed: 27 out of 37 stakeholders, from five different states, stated that cotton production in their area is less diverse (17; Andhra Pradesh, Madhya Pradesh, Maharashtra) or largely in monocropping (10; Gujarat, Haryana, Madhya Pradesh, Maharashtra). 10 respondents reported diverse (9; Madhya Pradesh, Odisha) and highly diverse (1; Maharashtra) cotton systems in their area. When asked about the reasons for less diverse cropping systems and challenges faced by the stakeholders in promoting crop diversification in their region, the most often stated reasons were the lack of cultivation infrastructure and resources of farmers (such as irrigation facilities, landholding, availability of labour, implements, machinery; mentioned by 54% of respondents), general reluctance of farmers to change their current cropping systems (49%) and the lack of awareness, knowledge or skills of farmers regarding crop diversification (46%). Other reasons were related to the low economical and risk bearing capacity of farmers (30%), market-related challenges (e.g. lack of stable markets for diversification crops, missing market linkages of farmers, farmers producing cash crops with the most attractive prices on the market; 19%) and other reasons (e.g. crop losses due to wild animals, lack of processing, transport, or storage facilities in the villages, unavailability of quality seeds, unfavourable policies, and lack of farmers' cooperatives and credit facilities; 24%).

Hence, while there is awareness of crop diversification among the cotton stakeholders, there is clearly room for improvement in the effective adoption of diversification practices. In a poll during the feedback workshops, 74% of the stakeholders regarded intercropping as the most important diversification practice, followed by crop rotation which 21% regarded as the most important practice. These correspond to the two main

diversification practices currently applied in organic cotton farms in India.

## 3.2 Main obstacles for the adoption of crop diversification

In their review on diversified crop rotations, Shah et al. (2021) identified a number of factors hampering their adoption, including: land fragmentation, limitation of resources (financial resources, information and expertise, machinery and infrastructure, etc.), scarcity of markets for diversified crops, limited availability of crop insurance and credits, and insufficient reinforcement and coordination between public and private institutions. In our study, we found similar barriers for diversification of cotton-based cropping systems and have grouped them into five main areas: i) market and procurement, ii) capacity building and knowledge transfer, iii) supply industry and infrastructure, iv) farmer motivation and women empowerment and v) policy environment. Figure 1 depicts causes and effects of poor diversification and how they are interlinked with each other in the problem tree.

### 3.2.1 Market and procurement

When it comes to the marketing aspects of diversified crops grown in rotation or as intercrops in a diversified cotton-based cropping system, there are three main challenges: i) lack of stable markets to sell the produce, ii) economy of scale and iii) insufficient market linkages.

As the majority of smallholder farmers are in rural areas, their only option to sell their diversified crop produce are often the local markets where there is no guarantee of purchase. The Minimum Support Prices (MSP) paid by public procurement cover 23 commodities (paddy, wheat, maize, sorghum, pearl millet, barley and ragi in the cereals group, gram, tur, moong, urad and lentils for pulses, groundnut, rapeseed-mustard, soybean, sesamum, sunflower, safflower and niger seed in the category of oilseed and the four commercial crops copra, sugarcane, cotton and raw jute). However, there is no price guarantee for diversification crops outside of these 23 commodities. And even for the crops where MSP apply, less than 25% of cotton farmers are aware of existing MSP and 75% of farmers who are aware of MSP did not sell their produce to public procurement (Aditya et al., 2017). Furthermore, intermediates and consumers may have no interest in small quantities of lesser-known crops – leading to a buyer monopoly where farmers do not have the negotiating power to define their products' prices.

For smallholder farmers, producing small quantities of multiple crops comes with logistic and economic challenges. Costs for transport and storage facilities become proportionally high and can diminish any profits made. When connecting farmers to local or selected urban markets via Farmer Producer Organizations (FPO), the main issues are

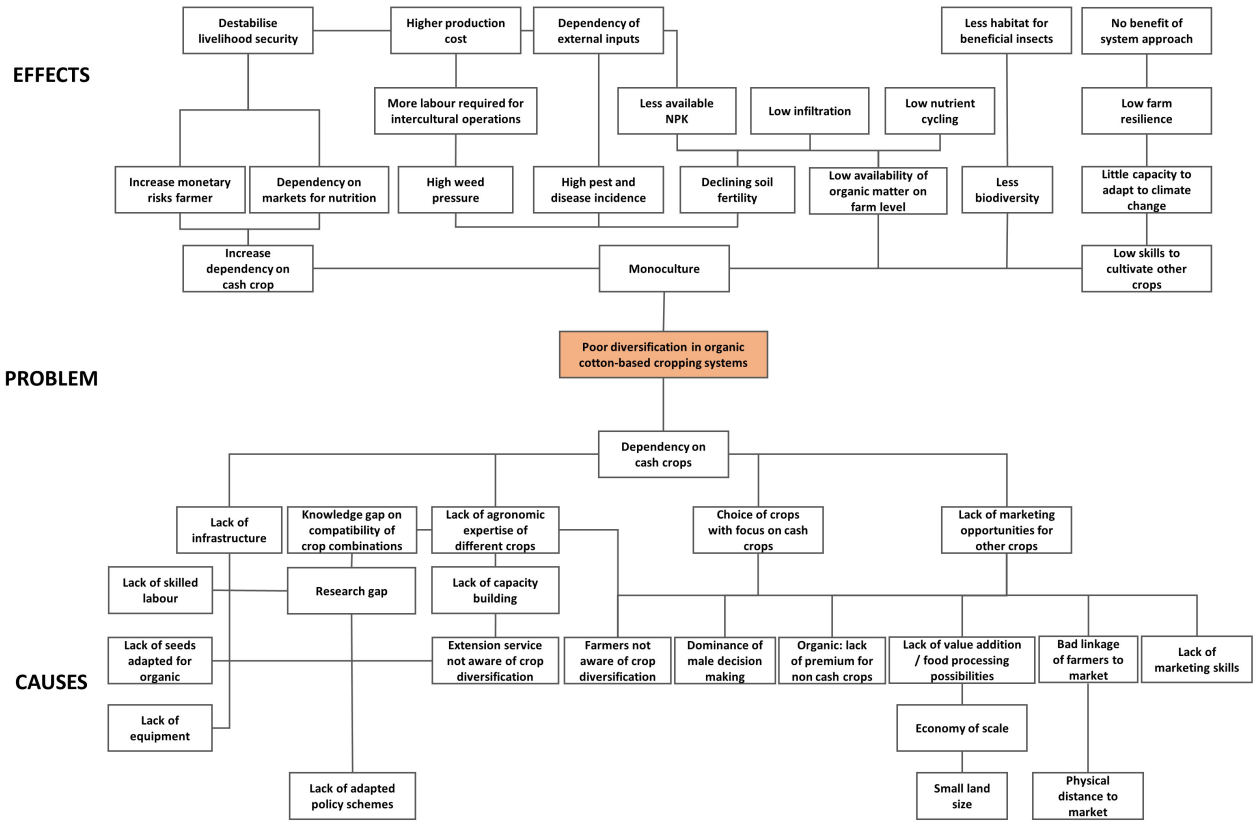


FIGURE 1
Problem tree analysis of causes and effects of poor diversification in organic cotton-based cropping systems.

the pooling of produce quantities, as well as the development and optimization of storage and transportation infrastructures.

Smallholder farmers are poorly linked to broader urban or international markets. 71% of the stakeholders in the market interview responded that farmers in their area only have the option to sell their diversification crops at the local market. Here, the engagements of the public sector, industry stakeholders, NGOs and Farmer Producer Organizations are required to establish the market linkages. To supply urban and international markets, higher degrees of processing up to packaging and branding activities are needed. This is especially important for organic farmers, as their produce is of higher quality complying with organic standards and needs to be distinguished so that they can be compensated accordingly. However, the implementation still remains a challenge despite existing policy scheme Paramparagat Krishi Vikas Yojana (PKVY) for the promotion of organic farming (Khurana and Kumar, 2020).

### 3.2.2 Capacity building and knowledge transfer

Organic farming is based on a system approach rather than a crop-centric and input-based logic, requiring good knowledge of the cropping system and its management. However, research and extension services and hence capacity building for farmers focus predominantly on the management of cash crops (such as cotton). Consequently, there is a lack of awareness among farmers about crop diversification and its benefits, as well as a knowledge gap on the compatibility of different crop combinations and their best management practices. Riar et al. (2020) showed that by choosing the appropriate crop rotation, yields could be increased by 60% on some cotton farms. Table 1 shows different recommended crop combinations for a diversified 2-year crop rotation, based on crop rotations recommended by the stakeholders interviewed and benefit-cost-calculations using data on crop-wise MSP and projected production costs reported by the Commission for Agricultural Costs and Prices for the season 2019-20 (Government of India, 2023a).

Farmers' lack of knowledge in crop diversification is one of the most mentioned challenges by stakeholders interviewed for the promotion of crop diversification and where they see the role of partners like extension services to provide the training, capacity building and awareness campaigns. The assessment of the Indian Council for Research on International Economic Relations (ICRIER; (Gulati et al., 2018)) and Joshi and Narayan (2019), however, paints a dark picture of the existing public extension and training services. In their study conducted in the state of Meghayala surveying 240 farmers, Joshi and Narayan (2019) found that "there is an evident gap that exists between the information services the government provides and what farmers need". The majority of farmers surveyed were unsatisfied with the extension services not being market-based (60%), lacking in providing access to market prices (93%) and credit schemes (96%) and insurance schemes (92%), the present extension program not being need-based (71%), lacking information on latest techniques (87%), and not being of sufficiently participatory nature (80%) (Joshi and Narayan, 2019). Furthermore, 40% of surveyed farmers did not receive any trainings by the extension services in the past three years (Joshi and Narayan, 2019). Gulati et al. (2018) reveal that the Indian government was spending only 0.7% of its GDPA on agriculture research, education, extension and training, in contrast to 2% recommended by the World Bank, where they see the source of many of the observed shortcomings of the existing public extension services in India.

Farmer Producer Organizations play a central role in aggregating farmers' produce from the region, creating market linkages, providing centralized infrastructure such as transport, storage and processing facilities and representing farmers' interests. The Government of India has launched a scheme for Formation & Promotion of 10'000 Farmer Producer Organizations (FPO) in 2020 to support their formation and development. Most FPO are still young, and their managers often lack professional agri-entrepreneurial skills relating to business management, marketing, networking and negotiation with industry and public sector actors (Government of India, 2020b). Strong capacity building initiatives are needed to improve efficiency and effectiveness of their services and the economic sustainability of the FPO's business models (SFAC, 2019).

### 3.2.3 Supply industry and infrastructure

Research and the supply industry are often focused on dominant crops, resulting in a lack of seeds and inputs for marginal crops, which might be ideal for crop diversification at the farm level. Especially in organic farming, access to high-quality seeds of cultivars adapted to local environmental conditions and organic farming practices without the use of synthetic inputs is of great importance. However, availability of quality seeds suitable for organic farming remain a challenge, and national initiatives to support production and use of organic fertilizers and biopesticides (National Project on Organic Farming) struggle to take off due to limited funding (Khurana and Kumar, 2020). For example, a

TABLE 1 Recommended crop combinations for a diversified 2-year crop rotation with cotton.

| | Year 1 | | Year 2 | |
|---|---|---|---|---|
| Crop rotation | Kharif (Jun – Nov) | Rabi (Oct – Mar) | Kharif (Jun – Nov) | Rabi (Oct – Mar) |
| Cotton + 3 Legumes | Cotton | Lentil | Soybean | Chickpea |
| Cotton + 2 Legumes + Oilseed | Cotton | Chickpea | Pigeon pea | Canola |
| Cotton + Oilseed + 2 Cereals | Cotton | Canola | Sorghum | Wheat |
| Cotton + 2 Cereals + Legume | Cotton | Wheat | Maize | Chickpea |
| Cotton + Oilseed + Cereal + Legume | Cotton | Canola | Pearl millet | Lentil |

parliamentary committee had estimated that 710 million tons of organic manure would be required nationwide for the season 2015-16, but only 338.7 million tons were produced (Khurana and Kumar, 2020).

About 62% of cotton production in India takes place under rainfed conditions (Chakraborty et al., 2022). Farmers without irrigation facilities for their fields are more reluctant to implement crop diversification, as the risk of crop failure caused by insufficient water supply is higher, especially for more water-intensive crops like vegetables or spices, and in the face of climate change. This was also reflected in the responses to the technical interview, where 24% of stakeholders interviewed specifically mentioned rainfed cultivation conditions, i.e. missing irrigation facilities of farmers, as a barrier for adoption of crop diversification in their area.

According to the stakeholders interviewed, labour shortage, especially at peak agricultural seasons, and increasing wages are other challenges that farmers face. The more labour-intensive diverse multi-cropping systems further intensify the demand for (skilled) labour (Feike et al., 2012; Chi et al., 2021). Higher mechanization of farms can help alleviate some of the labour shortages.

### 3.2.4 Farmer motivation and women empowerment

A general barrier is the low risk-bearing capacity and low economic status of many smallholder farmers. They are highly dependent on cultivation of cash crops (such as cotton) to generate their income. Incorporating more crops into the system requires crop- and rotation-specific knowledge and skilled labour, adapted equipment and implements, and adequate storage and marketing possibilities. All of which we have seen are not sufficiently available. Conversion to another cropping system can lead to variability of yields in the first years of the conversion phase, which is a significant risk to farmers. For example, during the first 2-3 years of conversion to organic cotton production, cotton yields can drop by 10-50% (Eyhorn et al., 2007). Thus, farmers are reluctant to change their cropping system away from what they have been growing, have the knowledge for and know the yields and income they can expect. This indicates the efforts required to strengthen the profitability of organic cotton production systems, as well as strengthening the extension system (Riar et al., 2020).

At the same time, by betting on one major crop for their entire income generation, smallholder farmers are put in a vulnerable position, e.g. in case of crop failure due to a year of bad climatic conditions. Diversification of the cropping system allows farmers to generate income from more than one main crop and thus to buffer economic risks during times of price volatility on the markets or when unfavourable conditions prevail for one crop. Studies have shown a yield stabilizing effect of intercropping under certain conditions (climatic, fertilization level, etc.) through asynchronous species-specific year-to-year variability in yield as compared to monocropping (Weih et al., 2021; López-Angulo et al., 2023). But yield variability can also increase depending on the crop combinations and environmental conditions (Weih et al., 2021), highlighting again the importance of research in and good knowledge of locally adapted crop diversification practices.

Stakeholder interviews revealed that there is a lack of credit facilities where smallholder farmers could take loans or get governmental financial assistance for initial investments when converting to more diverse farming systems. A report of the Government of India confirms the lack of easily available and affordable (with low interest rates) credits especially for small and marginal farmers, despite existing schemes such as the Interest Subvention Scheme (ISS) or the Kisan Credit Card (KCC) (Committee for Agricultural Policies and Action-Plans for a Secure and Sustainable Agriculture, 2019). A report of the Reserve Bank of India's Internal Working Group to Review Agricultural Credit in 2019 states that only 41% of small and marginal farmers (with landholdings up to 2 ha) were covered by credits from public and private sector banks (Reserve Bank of India, 2019), and Joshi and Narayan (2019) found that 92% of farmers surveyed in Meghalaya state lack access to information on available credit schemes. This fact, in connection with farmers' generally low risk-bearing capacity, is another barrier for the adoption of crop diversification.

One should also bear in mind the impact of gender roles in the decision-making processes on the farm. Compared to the male household members, women may have a higher interest in staple food production over cash crops and, therefore, be stronger advocates for crop diversification when given the decision power. However, even though women play an important role and are involved in a large part of the labour in cotton production, most decisions are taken by men (Eyhorn et al., 2005). Not only are women underrepresented in farmer associations and fewer women have contracts with cotton corporations, but they also have poorer access to inputs and their attendance in training sessions is lower (FAO-ICAC, 2015). Furthermore, despite improved land rights for women in existing policies, women are still faced with inequal land rights such as lower shares and land holdings of smaller size or inferior quality (Jain et al., 2023). While 73% of female rural workers were in the agricultural sector, only 14% of them owned agricultural land (Government of India, 2020a; Jain et al., 2023).

### 3.2.5 Policies

In the comprehensive analysis of the policies (Table S1), we find several gaps, summarized in Table 2. The table presents a comprehensive analysis of the gap between policy intentions and actual conditions regarding crop diversification in India. It reveals that despite policy support, there is a prevailing emphasis on monocropping driven by market stability concerns, hindering the adoption of diversified farming practices. This reliance on monoculture, particularly evident in cotton farming, leaves farmers vulnerable to market fluctuations. Additionally, policies focusing on profitable cash crops overlook the challenges in marketing diversified crops, resulting in limited access to premium prices. Soil fertility management policies, while aiming to enhance yields, fail to address soil degradation caused by monoculture, posing significant challenges to sustainability. Similarly, the acknowledgment of agrobiodiversity benefits within policies is not effectively translated into practical implementation, leading to ecological imbalances. Moreover, policies primarily incentivize crop specialization for economic gains,

TABLE 2 Key outcomes of gap analysis: Policy approaches vs. stakeholder interview revelations.

| Key Aspects | Policy Support in India | Policy Approaches | Actual Conditions | Gaps | Policy/ Literature References* |
|---|---|---|---|---|---|
| **Agrobiodiversity** | National Biodiversity Strategy and Action Plan, National Mission on Oilseeds and Oil Palm (NMOOP), Paramparagat Krishi Vikas Yojana (PKVY) | While there's acknowledgment of the significance of agrobiodiversity, policy implementation has been limited. There is a notable absence of emphasis on promoting the agronomic and environmental benefits of diversification within these initiatives. | Recent observations indicate a decline in agrobiodiversity, largely attributed to the prevalence of monoculture practices. This trend has led to heightened weed pressure and the depletion of habitats for beneficial insects. | Despite the recognition of agrobiodiversity benefits within policies, practical implementation falls short, resulting in ecological imbalances. Respondents have highlighted the absence of clear targets or goals related to crop diversification. Furthermore, there is a significant gap in promoting the agronomic and environmental advantages of diversification within existing policy frameworks. | Nos. 22, 26, 7 in Supplementary Table S1 |
| **Crop Diversification** | National Food Security Mission (NFSM), Rashtriya Krishi Vikas Yojana (RKVY), Crop Diversification Programmes by State Governments | Emphasis on monocropping for market stability | Respondents have highlighted a limited adoption of diversified cropping systems, primarily attributing it to the prevalent encouragement of monocropping driven by market demands and the absence of policy incentives. Consequently, there persists a continued reliance on cotton for income, leaving farmers increasingly vulnerable to market fluctuations. Furthermore, despite the availability of diverse practices such as crop rotations, intercropping, and agroforestry, their adoption remains constrained, particularly within organic cotton farming. | The insufficiency of emphasis within policies on promoting diversified cropping systems exacerbates the dependence on monoculture, impeding the adoption of alternative practices. Despite the diverse range of cropping techniques available, their adoption is hindered, especially in the realm of organic cotton farming. | Nos. 25, 27 in Supplementary Table S1 |
| **Market and Procurement** | Minimum Support Price (MSP) policy, e-NAM (National Agriculture Market), National Programme for Organic Production (NPOP) | Market-driven focus on profitable cash crops | Respondents have brought to light the challenges encountered in marketing and selling diversified crops, highlighting the limited access to premium prices for non-cash crops. | The policy framework overlooks the pivotal role of diversified farming systems in enhancing farmer resilience, instead emphasizing exclusively on economic incentives. | Nos. 4, 5, 29 in Supplementary Table S1 |
| **Extension Services** | Agricultural Extension Services, Krishi Vigyan Kendras (KVKs), National Institute of Agricultural Extension Management (MANAGE) | Emphasis on cash crop management | Participants have highlighted the deficiency in skills and resources necessary for diversification, hindering adaptation to evolving environments and markets. | The policy framework lacks adequate provisions for capacity building in diversified farming, resulting in a knowledge gap and restricted adoption of diversified practices. | Nos. 15, 16, 17 in Supplementary Table S1 |
| **Soil Fertility Management** | National Mission for Sustainable Agriculture (NMSA), Soil Health Card Scheme, National Programme on Organic Production (NPOP) | The prevailing emphasis within these policies is on increasing yields to meet growing agricultural demands. However, there is growing concern over declining soil fertility attributed to monoculture practices and | Respondents have identified a troubling trend of diminishing soil fertility due to widespread monoculture and input-intensive farming practices. This has resulted in reduced water absorption and nutrient availability for plants, posing significant challenges to agricultural productivity and sustainability. | Regardless of policy emphasis on yield enhancement, empirical evidence reveals soil fertility degradation and heightened dependence on external inputs. Additionally, the inadequacy of quality organic inputs exacerbates the situation. Notably, targeted research addressing organic farmers' soil fertility needs emerges as a pressing concern. | Nos. 4, 5, 23, 24 in Supplementary Table S1 |

*(Continued)*

TABLE 2 Continued

| Key Aspects | Policy Support in India | Policy Approaches | Actual Conditions | Gaps | Policy/ Literature References* |
|---|---|---|---|---|---|
| | | intensive farming methods. | | | |
| **Farmer Resilience** | National Food Security Mission (NFSM), Rashtriya Krishi Vikas Yojana (RKVY), Pradhan Mantri Krishi Sinchayee Yojana (PMKSY), Mission Organic Value Chain Development for North Eastern Region (MOVCD-NER) | Incentivizing crop specialization for economic gains | Farmers grapple with challenges in adapting to evolving environments and markets due to inadequate skills and resources for diversification. | The prevailing policy framework overlooks the critical role of diversified farming systems in cultivating farmer resilience, instead concentrating solely on economic incentives. | Nos. 16, 25, 27, 28 in Supplementary Table S1 |
| **Farm Profile of Organic Cotton Farms** | National Food Security Mission (NFSM) | No specific policy targeting farm profile exists | The average farm size was noted to be 2 hectares (range: 1-4 hectares), with the majority situated in remote areas characterized by low levels of formal education. Despite organic regulations, there was limited diversification observed among farms. | Policy fails to address the challenges faced by smallholder organic cotton farmers, including limited diversification opportunities and low levels of formal education. | No. 25 in Supplementary Table S1 |
| **Gender Dynamics** | National Policy for Empowerment of Women, Mahila Kisan Sashaktikaran Pariyojana (MKSP), Women Farmers' Entitlements under various government schemes | Limited consideration in policy formulation | Respondents have identified gender disparities in decision-making, with male dominance in crop selection favouring cash crops over staple food production. | The existing policy framework overlooks the gender dimensions of agricultural decision-making, perpetuating inequalities in crop diversification and hindering the empowerment of women in agriculture. | No. 30 in Supplementary Table S1 |

*For detailed references, please refer to Supplementary Table S1.

overlooking the role of diversified farming in building farmer resilience. Inadequate provisions for capacity building in diversified farming and the neglect of gender dynamics in policy formulation further exacerbate the gap. Lastly, the lack of specificity in addressing challenges faced by smallholder organic cotton farmers underscores the need for policy adjustments to promote diversified farming practices and address associated challenges effectively.

Several policy schemes and programs by the Government of India address a number of the challenges mentioned earlier (Government of India, 2018; Committee for Agricultural Policies and Action-Plans for a Secure and Sustainable Agriculture, 2019; Table S1).

- The *National Food Security Mission (NFSM)* aims to increase production of rice, wheat, pulses, coarse cereals and commercial crops, among other things, by restoring soil fertility and productivity.
- Under the *National Mission for Sustainable Agriculture (NMSA)*, farmers receive support for up to 50% of input costs in integrated farming systems.
- The *Agricultural Marketing Infrastructure (AMI)* implemented since 2014 provides a platform for online marketing of agri-commodities across the country.
- Through the *Paramparagat Krishi Vikas Yojna (PKVY)*, organic farming is promoted with support for marketing, common packaging and branding, transport, value addition infrastructure through FPO/FPC, local publicity and participation in local and national fairs, consultation with lead farmers.
- In the North-Eastern states, the *Mission Organic Value Chain Development for North Eastern Region* provides a comprehensive scheme for the development of commercial organic farming clusters addressing the entire value chain from production and processing to marketing.
- The *Mission for Integrated Development of Horticulture (MIDH)* aims at the holistic growth of the horticulture sector through regionally differentiated strategies covering research, extension, promotion of technologies, post-harvest management, processing, marketing, aggregation of farmers to FPO, improved productivity through quality seeds and planting

material, promotion of micro irrigation, and skill development and generation of employment opportunities for the rural youth. The sub-schemes *National Horticulture Mission (NHM)* and *Horticulture Mission for North-East and Himalayan States (HMNEH)* provide, among other things, subsidies of 40% of costs for planting material for spices, aromatic plants and flowers (which can be profitable diversification crops), subsidies for the creation of water harvesting systems for individual farmers or communities and subsidies during three years for conversion to an organic farming system.

- Farmers can reduce their risk in case of crop failure through *Pradhan Mantri Fasal Bima Yojana (PMFBY)* and the *Weather Based Crop Insurance Scheme (WBCIS)*. They cover insurance protection for food crops, oilseeds, and annual horticultural and commercial crops in case of crop failure due to adverse weather/climate and post-harvest loss caused by cyclonic rain and unseasonal rain.
- Conservation of soil and water through good agricultural practices was the aim *of Pradhan Mantri Krishi Sinchai Yojana*, implemented for five years from 2015. It included adoption of crop diversification, seed production and nursery raising in water-logged areas and adoption of drip and sprinkler irrigation systems. Other missions, such as *NFSM* and *Bringing Green Revolution to Eastern India (BGREI)*, also offer support for water harvesting and irrigation infrastructure.
- Several schemes offer subsidies for the production and distribution of quality seeds: *BGREI* (for rice and wheat), *NFSM* (rice, wheat, coarse cereals, pulses), *National Mission on Oilseed & Oil Palm (NMOOP)* (groundnut, soybean sunflower, safflower, sesame, niger, mustard, rapeseed, linseed and castor) and *Sub-Mission on Seed and Planting Material (SMSP)* (50% cost of seeds of cereals, 60-75% of the cost of seeds of oilseeds, pulses, fodder, green manure crops etc.).
- In 2010, the *National Mission on Agriculture Extension and Technology (NMAET)* was launched to restructure and strengthen the agricultural extension services and enabling them to disseminate appropriate technologies and improved agricultural practices to farmers. It consists of four sub-missions: *Sub-Mission on Agricultural Extension (SMAE), Sub-Mission on Seed and Planting Material (SMSP), Sub-Mission on Agricultural Mechanization (SMAM)*, and *Sub-Mission on Plant Protection and Plant Quarantine (SMPP)*. Farmers' access to agricultural machinery is addressed in the *SMAM*. It offers financial assistance for procurement of farm machinery and equipment and provides training for the proper use and maintenance of the machinery.
- Around 24'000 agricultural extension functionaries are employed at the administrative division level of blocks. They are the contact points for farmers for queries regarding schemes, appropriate technologies etc. Additionally, farmers can contact agents of the Kisan call centres operating 365 days a year via a toll-free number. Location-specific information such as weather information, market information, good practices, dealer network and availability of inputs is accessible via Kisan call centres, SMS service, the "Farmers' Portal" online platform and Kisan Suvidha mobile app. Furthermore, there are various training programmes and assistance in the topics of seed production, plant protection, agricultural machinery and equipment and post-harvest management in the form of farm schools, demonstration plots and exposure visits for farmers, front-line demonstrations and demonstrations of improved packages of practices by states.

Despite the vast number of existing policies, missions and sub-missions addressing many of the challenges mentioned above in areas such as marketing and procurement, capacity building and training, availability of seeds and inputs and cultivation infrastructure and machinery, these remain areas of concern for the wider adoption of crop diversification as part of a sustainable agricultural landscape in India. A poll with participants of the feedback workshop showed that 37% of respondents did not regard the existing policy environment as beneficial for crop diversification, and 47% were unsure about it.

In manoeuvring through the existing Indian agricultural policy landscape, a number of challenges stood out. Some schemes above have only regional reach or target only rice-based farming systems. Many policy schemes are based on a crop or commodity-based logic, rather than a system-based one, and are therefore limited in their ability to address environmental and socio-economic challenges holistically. A number of government interventions provide financial support to farmers (e.g. for inputs, machinery, etc.), but are limited in their scope to few years. If such interventions are not accompanied by sustainable structural changes empowering farmers, they may be unattractive to farmers due to uncertainty on whether they will be profitable after the funding scheme ends.

The large number of independent policies, missions and submissions, as well as involved ministries and departments makes it difficult to align targets coherently and complicate data gathering and monitoring of progress made (Khurana and Kumar, 2020; Priyadarshini and Abhilash, 2020). They also impede farmers, FPO, and other beneficiaries to be aware of and comprehend the existing supporting initiatives. Especially smallholder farmers lack awareness about existing policies and schemes for which they would be eligible, such as MSP, social security schemes for farmers (*Pradhan Mantri Kisan Maandhan Yojana (PM-KMY)*), and crop insurance scheme (*Pradhan Mantri Fasal Bima Yojna (PMFBY)*) (stakeholder interviews, Aditya et al., 2017; CACP, 2021, CACP,2022). Aditya et al. (2017) revealed that over 75% of farmers from rural agricultural households did not know about existing MSP prices for their crops produced. This is very concerning for a procurement system that has been around since 1966-67.

## 4 Way forward and policy implications of inferences

In the domain of market and procurement, it is imperative for industry stakeholders and the public sector to invest in market

research. This research is crucial for identifying gaps between supply and demand for crops suitable for cotton-based farming systems and for recognizing opportunities to enhance market linkages within the existing supply chain, catering to diverse farm groups. Key actors in this endeavour include state Agriculture Departments, State Agricultural Universities, research institutes, and KVKs (Krishi Vigyan Kendras), which can conduct advanced market research to inform policy development concerning crop diversification.

Farmers require stable and appealing price environments to transition their cropping systems sustainably, while minimizing risks. Extending the Minimum Support Price (MSP) to a variety of crops suitable for diversification in cotton-based farming systems, such as cowpea, sunn hemp, castor, and linseed, where there is demand, is recommended. Moreover, organic farmers, who employ sustainable production methods, necessitate access to markets where their efforts are rewarded with premium prices for organic produce. NGOs, Farmer Producer Organizations (FPOs), and the industry can facilitate the establishment of networks connecting these farmers to organizations willing to offer premium prices, while also aiding in processing and marketing activities to tap into broader urban and international markets.

Establishing a robust market infrastructure is crucial for promoting crop diversification in cotton-based farming systems. FPOs can play a pivotal role in collecting diversified produce from farmers, ensuring a purchase guarantee, and addressing the challenge of economies of scale through centralized transportation and storage facilities. Additionally, the installation of household processing units or small-scale local processing plants can enable local processing and value addition, rendering diversification produce more marketable and profitable.

FPOs hold significant potential in making crop diversification profitable by serving as the key link between farmers and the entire agricultural value chain. As of August 2022, 3,179 FPOs were registered under the Central Sector Scheme "Formation and Promotion of 10,000 Farmer Producer Organizations" initiated by the Government of India in 2020 (Government of India, 2022). However, since most FPOs are still in their nascent stage, it is imperative to provide them with professional managerial support, strategic hiring, and business skills training to effectively strengthen market linkages and post-harvest infrastructure (CACP, 2021). This responsibility falls under the purview of cluster-based business organizations (CBBOs) at the state or cluster level, formed under the scheme (Government of India, 2020b).

To address the identified shortcomings in capacity building and knowledge transfer, it is highly recommended that the Indian Council of Agricultural Research (ICAR) leverages its robust infrastructure and institutional network to bolster region-specific research activities. These activities should focus on identifying suitable crop combinations and their best management practices in diversified cotton-based production systems. Maximum efforts should be directed towards updating crop production technology and implementing improved package of practices. KVKs should prioritize capacity building, dissemination of region-specific knowledge and recommendations, and awareness campaigns targeting FPOs and farmers. Additionally, they should ensure that key insights and recommendations reach state and central governments to influence their policies and strategies regarding crop diversification.

Efforts to improve the availability and accessibility of suitable inputs and infrastructure require active involvement from public research institutes and industry partners. This entails advancing research and development of adapted cultivars suitable for crop diversification and organic production, as well as bio-inputs. Extension services and FPOs can serve as conduits to farmers, providing them with quality seeds, inputs, and necessary training and support for cultivating various cultivars. Policies aimed at enhancing water availability, such as incentivizing the adoption of water-efficient irrigation technologies like drip irrigation and promoting water harvesting structures, can further incentivize farmers to diversify crops, especially in rainfed regions.

To address the shortage of skilled labour, extension services must invest in adequate training for farmers on crop diversification, specific management techniques, and technologies. Implementing centralized hiring systems facilitates farm mechanization without requiring significant investments in agricultural machinery. Such systems, established under the Sub-Mission on Agricultural Mechanization (SMAM), should be further promoted and strengthened (CACP, 2022).

Raising awareness among farmers about the benefits of crop diversification, such as improved soil fertility, reduced input requirements, and breaking pest cycles, is crucial. Extension services play a pivotal role in disseminating knowledge about these benefits and transferring technical know-how on managing multi-crop systems. Access to processing infrastructure for local value addition can further encourage crop diversification and benefit women by creating more employment opportunities and income, as they often engage in post-harvest processing activities.

Crop diversification not only enhances household food security by providing nutritional food but also presents opportunities for empowering women. Women often prioritize household food security alongside profitability when choosing crops to grow. Therefore, empowering women and involving them in decision-making processes can promote crop diversification. Studies suggest that equal access to productive resources in agriculture can lead to significant yield gains and increase total agricultural outputs in developing countries by up to 4% (FAO, 2011). Ensuring equitable distribution of landholding rights is crucial for enhancing women's decision-making power (Jain et al., 2023). Various measures, including awareness campaigns, education on women's land rights, and standardized land records, can promote gender equality in agriculture. Initiatives like the Mahila Kisan Sashaktikaran Pariyojana (MKSP) by the Ministry of Rural Development aim to improve women's status and opportunities in agriculture through training and access to government inputs and services.

Despite numerous policies and schemes addressing various aspects mentioned above, there is still a gap in creating an environment conducive to crop diversification. A holistic national strategy is required to make diversified crop production more attractive and profitable than the prevailing focus on cash crops.

One approach could be to promote organic production, as it inherently entails crop diversification and embraces sustainable production principles. Policies like the National Programme for Organic Production (NPOP) and the Paramparagat Krishi Vikas Yojna (PKVY) have been launched to promote organic farming, but there is a need for a more ambitious and coherent national policy framework, as suggested by various experts (Committee for Agricultural Policies and Action-Plans for a Secure and Sustainable Agriculture, 2019; Khurana and Kumar, 2020; Priyadarshini and Abhilash, 2020).

Moreover, there is a lack of awareness among farmers regarding existing supportive policies and schemes. Collaboration between extension services, FPOs, and the public sector is crucial for conducting awareness campaigns and making information easily accessible to farmers. Only through a comprehensive approach addressing all aspects can crop diversification be effectively implemented, unlocking its potential to support rural livelihoods and enhance the sustainability of agricultural production systems.

## 5 Conclusion

The current landscape of crop diversification among cotton farmers in India reflects both opportunities and challenges. With over 70% of cotton farmers being smallholders, the dependence on cash crops for income generation is significant, driven by relatively stable markets and profitable prices (Government of India, 2020a). However, studies indicate that diversified cotton production systems can outperform monocropping in terms of profitability, presenting an enticing prospect for farmers to mitigate risks and enhance profitability.

Despite the potential benefits, the adoption of crop diversification practices faces several obstacles. Market and procurement challenges include the lack of stable markets, issues with economies of scale, and inadequate market linkages. Smallholder farmers often struggle to access broader urban or international markets, relying primarily on local markets where pricing and demand are uncertain. Farmer Producer Organizations (FPOs) and government initiatives like the Minimum Support Price (MSP) scheme aim to address some of these challenges but fall short in providing adequate support for diversified crops.

Capacity building and knowledge transfer remain critical, with farmers lacking awareness of crop diversification benefits and facing a knowledge gap in crop management practices. Extension services and FPOs play a crucial role in bridging this gap, but shortcomings in existing public extension services hinder effective knowledge dissemination.

The supply industry and infrastructure also pose challenges, with a focus on dominant crops leading to limited availability of seeds and inputs for diversified crops. Additionally, rainfed conditions, labour shortages, and limited access to credit further impede crop diversification efforts. Gender disparities in decision-making and land rights further exacerbate these challenges, underscoring the need for women's empowerment and equitable access to resources.

Addressing these obstacles requires a multifaceted approach involving stakeholders at various levels, including government bodies, industry players, NGOs, and farmer organizations. Capacity building initiatives, improved market access, targeted extension services, and policy interventions aimed at enhancing credit accessibility and empowering women are essential to unlock the potential of crop diversification in cotton farming systems. By overcoming these challenges collectively, India can foster sustainable agricultural practices, improve farmer livelihoods, and enhance the resilience of its agricultural production systems for the future.

## Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## Author contributions

CK: Writing – original draft, Writing – review & editing, Visualization. SJ: Investigation, Writing – review & editing, Formal analysis. TJ: Investigation, Writing – review & editing, Formal analysis. EG: Investigation, Writing – review & editing, Formal analysis. AR: Funding acquisition, Investigation, Project administration, Writing – review & editing, Supervision.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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## Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fagro.2024.1370878/full#supplementary-material

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