

Climate Risk Insurance for Farmers in India: Effectiveness, Gaps and Emerging Technology

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ABSTRACT

Agricultural productivity and incomes are greatly affected by the variability of climate conditions and the occurrence of extreme weather, which are also especially damaging for small and marginal farmers. Climate risk insurance helps to transfer parts of the risk and improve financial resilience of farmers. This paper explores the effectiveness of agricultural climate risk insurance and its key gaps, paying special attention to India. The research is based on the existing secondary literature, government reports, and available evidence, with PMFBY scheme in India used as an example of agricultural climate risk insurance in the country and IBLI project in East Africa as a comparison tool. Basis risk, delayed claims, lack of awareness of farmers, data problems, affordability, and institutional coordination are among the main barriers. New technologies such as remote sensing, YES-TECH, WINDS, and claims through smartphone are possible options for improving insurance. Technology alone is not enough for proper functioning of agricultural climate risk insurance; suitable products, settlements, good data, and farmers' involvement are also necessary.

Keywords: Climate risk insurance; PMFBY; crop insurance; basis risk; index insurance; smallholder farmers; remote sensing; agricultural risk management

1. Introduction

Agriculture is highly vulnerable to climate and weather-related risks such as droughts, floods, cyclones, heat stress, and unpredictable rains. Such events may result in reduced yield, lower farm incomes, and low household resilience, especially for smallholder and marginal farmers due to their low ability to cope with repetitive losses. The IPCC recognizes climate-related extremes as a key risk to agricultural production and food security and uses insurance as a financing mechanism for climate-related risks (IPCC, 2022).

Increasing frequency and intensity of disasters have led to large losses of agricultural production. FAO

data shows that disasters accounted for losses of more than USD 108 billion in crop and livestock production in developing countries between 2008 and 2018, where the share of losses due to drought was significant (FAO, 2021). This highlights the need for mechanisms that can provide timely financial support to farmers after climate-related losses.

Climate Risk Insurance (CRI) is one such mechanism that transfers part of the financial consequences of climate-related shocks from farmers to insurers. It may be based on actual farm losses (indemnity insurance) or on a predefined index such as rainfall, temperature or vegetation conditions (index insurance). Index-based

products can reduce some costs associated with individual loss assessment, but they may also create basis risk, where the insurance payout does not correspond closely to the farmer's actual loss (IPCC, 2022).

The effectiveness of agricultural insurance depends not only on the availability of insurance but also on affordability, farmer awareness, trust, data quality and timely claim settlement. Evidence from India shows that farmers' demand for weather insurance can be affected by price, liquidity constraints and trust, while other research suggests that weather-index insurance may not always provide sufficient protection against farm-level yield variation (Cole et al., 2013; Michler et al., 2022).

In India, the Pradhan Mantri Fasal Bima Yojana (PMFBY), introduced in 2016, is the country's major crop insurance programme. It aims to provide financial support to farmers suffering crop losses from insured risks while supporting income stability and agricultural investment. Under the scheme, farmer premium contributions are capped at 2% for Kharif foodgrain and oilseed crops, 1.5% for Rabi crops and 5% for annual commercial and horticultural crops. Recent reforms have also emphasized technology-based crop yield estimation, weather data and digital claim processing (Gol, 2020).

Therefore, this paper examines the effectiveness and major gaps of climate risk insurance in India, with the Pradhan Mantri Fasal Bima Yojana (PMFBY) as the principal case study. It also examines the role of emerging technologies in improving insurance delivery and draws lessons from the Index-Based Livestock Insurance (IBLI) programme in East Africa. The analysis focuses on insurance effectiveness, farmer participation, basis risk, claim settlement, affordability, data availability and technology-enabled delivery.

2. Methodology

This study adopted a narrative review and comparative case-study approach. Secondary information

was collected from peer-reviewed journal articles, reports of international organisations and Government of India publications relating to agricultural insurance, climate risk, PMFBY, RWBCIS and index-based insurance. Recent literature was prioritized for the Indian context, while seminal and widely cited studies were retained to establish the conceptual and empirical foundations of agricultural insurance.. The analysis focused on five dimensions: insurance design, farmer participation, claim settlement, basis risk and technology-enabled delivery. PMFBY was selected as the principal Indian case study because of its national scale, while IBLI was selected as an international comparator because of its established use of satellite-based index insurance. The findings were synthesised qualitatively rather than through a formal meta-analysis.

3. Evidence from Past Studies

The reviewed studies indicate from the above table, that the effectiveness of agricultural insurance depends on both product design and farmer-level factors. Evidence from India highlights the importance of price, liquidity and trust in farmer participation, while research on weather-index insurance points to the problem of basis risk. Insurances in East Africa show that index insurance can help reduce exposure to climate risks but it does not cover all uninsured risks. The implications of these findings are that insuring alone will not be enough but proper index design and proper implementation will be essential for proper risk protection.

3.1. Research Gap

Previous studies have proven that agricultural insurance helps reduce the impact of climate-induced losses on farmers. However, issues like basis risk, farmers' participation, costs, data availability, and prompt claims handling continue to limit its efficacy. In India, the increasing use of remote sensing, weather information

Table 1. Summary of Selected Studies on Agricultural and Climate Risk Insurance

Study	Context	Key finding	Relevance to this paper
Cole et al. (2013)	India - rainfall insurance	Demand was affected by price, liquidity constraints and trust	Explains challenges in farmer participation
Michler et al. (2022)	India – weather-index insurance	Weather explained only part of crop-yield variation	Highlights basis-risk concerns
Jensen et al. (2016)	East Africa – IBLI	Index insurance can support resilience, but uptake remains challenging	Provides international comparison
Carter et al. (2017)	Index insurance	Insurance can help households manage climate-related shocks	Establishes the resilience role of insurance
Nayak et al. (2020)	India – crop insurance	Identified implementation and participation challenges	Provides Indian crop-insurance context

Source: Compiled from the studies cited in the table.

and digital technologies under PMFBY creates an opportunity to improve insurance delivery. However, the effectiveness of these technological interventions and their ability to address existing institutional and farmer-level constraints require further consideration. Therefore, this paper examines PMFBY from the perspectives of effectiveness, implementation gaps and technology, while drawing lessons from IBLI in East Africa.

4. Climate Risk Insurance: Concept and Types

4.1 Concept of Climate Risk Insurance

Climate Risk Insurance (CRI) is a risk-transfer mechanism through which farmers or other agricultural stakeholders pay a premium to receive financial compensation when specified climate-related risks cause insured losses. It can help farmers protect income, maintain consumption and continue investment following adverse climatic events.

Climate risk insurance can broadly be classified into indemnity-based insurance and index-based insurance.

4.2 Indemnity-Based and Index-Based Insurance

It is evident from Table 2 that indemnity-based insurance provides a closer link between the actual farm loss and the insurance payout but requires field-level

assessment, which can increase administrative costs and settlement time. Index-based insurance can reduce the need for loss determination on an individual basis, and hence make the process faster and cheaper. But the payout is dependent on how well the selected index performs. This means that choosing one of these methods will have to weigh precision against efficiency.

4.3 Basis Risk

The basis risk is one of the greatest challenges of index-based agriculture insurance. It is characterized by the fact that there is no close correlation between the payment made and the loss suffered. It can arise because the geographical area used for calculating an index may experience different weather or yield conditions from an individual farmer's field, resulting in either inadequate compensation or a payout that does not correspond to the farmer's actual loss.

5. PMFBY in India: Design, Performance and Gaps

5.1 Evolution of Crop Insurance in India

India has progressively developed crop insurance programmes to protect farmers from production risks. Important milestones include the experimental crop insurance initiatives introduced in the early 1970s,

Table 2. Comparison of Indemnity-Based and Index-Based Agricultural Insurance

Parameter	Indemnity-based insurance	Index-based insurance
Trigger	Actual assessed loss	Predefined index
Assessment	Farm/field-level assessment	Weather, yield or vegetation data
Administrative cost	Relatively high	Relatively lower
Basis risk	Generally lower	Important concern
Payout	Based on assessed loss	Based on index threshold
Major advantage	Closely linked to actual loss	Faster and potentially less costly
Major limitation	Costly and time-consuming assessment	Payout may not match actual farm loss

Source: Compiled by the author based on literature on indemnity- and index-based insurance.

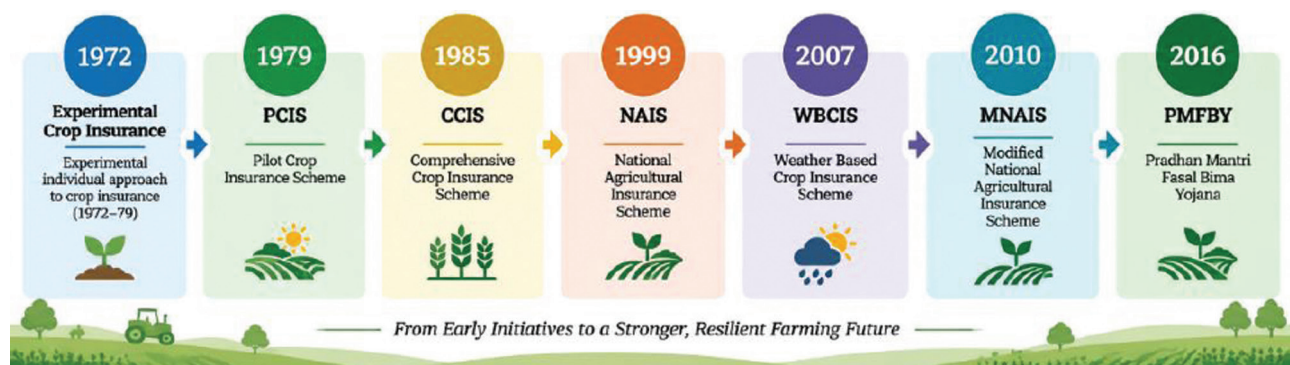


Figure 1. Evolution of Crop Insurance in India

Source: Compiled from Government of India/PMFBY historical documents.

the Pilot Crop Insurance Scheme (PCIS) in 1979, the Comprehensive Crop Insurance Scheme (CCIS) in 1985, the National Agricultural Insurance Scheme (NAIS) in 1999, the Weather Based Crop Insurance Scheme (WBCIS), the Modified NAIS (MNAIS) in 2010 and PMFBY in 2016.

5.2 PMFBY: Design and Objectives

The Pradhan Mantri Fasal Bima Yojana (PMFBY) was introduced in 2016 with the objective of providing financial support to farmers suffering crop losses due to specified risks. The scheme also aims to stabilize farm income, encourage modern agricultural practices and maintain agricultural credit flow.

The farmer's premium contribution is capped at 2% of the sum insured for Kharif food grain and oilseed crops, 1.5% for Rabi crops and 5% for annual commercial and horticultural crops (Gol, 2020).

PMFBY has subsequently incorporated greater use of technology, including remote sensing, improved crop-yield estimation, weather data and digital claim processing.

5.3 Performance and Scale of PMFBY

PMFBY has achieved substantial national scale since its introduction. According to Government of India data as of August 2026, from Kharif 2016 to Rabi 2025–26, more than 92.46 crore farmer applications were insured and more than 26.33 crore applications received claims amounting to over ₹2.06 lakh crore.

Table 3. Selected PMFBY Performance Indicators

Indicator	PMFBY
Period	Kharif 2016–Rabi 2025–26
Farmer applications insured	>92.46 crore
Applications receiving claims	>26.33 crore
Claims paid	>₹2.06 lakh crore

Source: Government of India (2026)

The figures from the above table demonstrate the very large scale of PMFBY in terms of insurance coverage and financial compensation. More than 92 crore farmer applications have been insured since the scheme's introduction, while more than 26 crore applications have received claims. The difference between these figures should not be interpreted as a failure of the scheme, because an insurance claim arises only when an insured loss occurs. The data instead demonstrate both the extensive reach of PMFBY and the substantial financial support provided to farmers experiencing insured losses.

6. Major Gaps in PMFBY

From Table 4, there are several areas where weaknesses in the design and execution of PMFBY are revealed. These include basis risk as well as data issues which influence loss estimation accuracy, and delays in filing claims, lack of awareness, and trust which can decrease the value and involvement of farmers. Together, such weaknesses seem to imply that any improvements to the outcomes of insurance require technological, as well as practical and institutional advancements.

6.1 Basis Risk

The concept of basis risk is very important for index insurance and area-based insurance. The number of losses that a farmer suffers in his/her particular field can be different from those experienced on the average for the insurance unit, resulting in inadequate compensation or even compensation despite little losses.

6.2 Claim Settlement

Timely compensation is essential because farmers need immediate money after suffering a loss in order to buy seed, fertilizer, and other materials for the next planting season. Delayed payments reduce the efficiency of insurance as an effective risk management tool. (Nayak et al., 2020).

Table 4. Major Gaps and Implementation Challenges in PMFBY

Major gap	Problem	Implication
Basis risk	Area-level/index assessment may differ from individual farm loss	Farmer may receive inadequate compensation
Claim delays	Settlement may take considerable time	Reduces usefulness of insurance
Limited awareness	Farmers may not fully understand coverage and triggers	Affects participation and expectations
Data limitations	Yield and weather data may have spatial/temporal limitations	Can affect assessment accuracy
Affordability	Premiums and indirect participation costs can remain concerns	May restrict voluntary participation
Trust	Delays or unexpected payouts can reduce confidence	Weakens future participation
Institutional coordination	Multiple agencies are involved in implementation	Can create administrative difficulties

Source: Compiled by the author from the available literature and references given in the text.

6.3 Farmer Awareness and Trust

The effectiveness of insurance depends upon farmers' knowledge regarding risks insured, premiums, loss assessment, and claims criteria. Similarly, previous research conducted in India has stressed that trust and liquidity are important determinants for taking insurance.

7. Technology-Enabled Climate Risk Insurance

Technology is increasingly being incorporated into agricultural insurance to improve measurement, transparency and speed.

7.1 Remote Sensing

Satellite-based remote sensing can provide information related to the size of the area covered by crops, health of the vegetation, and growth of crops in extensive geographical locations.

7.2 YES-TECH

YES-TECH (Yield Estimation System Based on Technology) uses technology-based approaches for improving yield estimation of crops under the PMFBY scheme. It seeks to decrease the dependency on conventional crop cutting approach and increase accuracy in yield estimation process.

7.3 WINDS

The Weather Information Network and Data System (WINDS) aims to improve weather data access and extend

the geographic scope of meteorological information. Improved weather data would help to carry out a proper risk assessment and develop insurance products.

7.4 Digital Claim Settlement

Digital systems such as DigiClaim can support electronic processing and settlement of insurance claims, potentially reduce administrative delays and improve transparency.

Most of the technologies discussed in Table 5 focus on overcoming two main limitations associated with agricultural insurance, namely the quality of information used to assess the risk and the effectiveness of the claims processing. On the one hand, YES-TECH and remote sensing help with yield and crop assessment. On the other hand, WINDS improves weather information and DigiClaim enables online claims processing. Still, these technologies should be considered only as supporting means rather than all-encompassing solutions since affordability, farmer education, trust, and product design remain important factors.

8. IBLI in East Africa: Lessons for India

The IBLI project stands as a relevant example of index-based insurance at the international level. Designed for use by pastoralist communities in East Africa, IBLI uses satellite information about vegetation to gauge drought-induced livestock losses. Unlike the PMFBY project, which is primarily concerned with crop production, IBLI focuses

Table 5. Major Technologies Relevant to PMFBY

Technology/system	Main function	Potential benefit
YES-TECH	Technology-based yield estimation	Improved yield assessment
WINDS	Weather data infrastructure	Better risk assessment
Remote sensing	Crop monitoring	Wider and faster assessment
CCE-Agri App	Digital crop-cutting information	Improved data recording
DigiClaim	Digital claim processing	Faster and more transparent settlement

Source: Compiled by the author from the available literature and references given in the text.

Table 6. PMFBY and IBLI: Comparison

Feature	PMFBY	IBLI
Main sector	Crops	Livestock
Main risk	Crop production risks	Drought/forage scarcity
Geographic focus	India	East Africa
Index/data approach	Yield, weather and technological assessment	Satellite-derived vegetation index
Major strength	Very large scale	Innovative satellite-based insurance
Major challenge	Basis risk, delays and participation	Basis risk and uptake
Key lesson	Technology can support large-scale delivery	Index design and farmer engagement are critical

Source: Compiled by the author from the available literature and references given in the text.

on livestock. IBLI illustrates the usefulness of using satellite indices to offer insurance services when assessing farm losses through traditional methods is difficult. However, IBLI also points out some of the challenges faced by index insurance schemes such as basis risk.

Based on the IBLI experience, it is important that the design of index should take into consideration the risk faced by the farmers. In addition, education and communications of farmers have an important role in improving their knowledge. Jensen et al. (2016) also found that IBLI decreased the exposure of farmers to covariate risks; however, there was still a high degree of basis risk.

9. Limitations of the Study

This study is based primarily on secondary information from peer-reviewed literature, government publications and institutional reports. It does not include primary data collected directly from farmers, insurers or implementing agencies. The study also does not undertake econometric analysis or a formal systematic review of the literature. Therefore, the findings should be interpreted as a qualitative assessment of the available evidence on climate risk insurance, PMFBY and IBLI rather than as a direct measurement of causal impacts or farmer-level outcomes.

10. Policy Suggestions and Conclusion

The effectiveness of climate risk insurance in India can be improved by reducing basis risk through localized indices, better crop-yield estimation, remote sensing and improved weather-data infrastructure. Claims resolution should be speedy and transparent by virtue of digitalization and technological assessment of losses, and there should be an increase in the level of awareness of farmers so that they may comprehend coverage, triggers, and claims process. The insurance should be customized for local crops and climate risk rather than adopting standardized solutions in heterogeneous areas. The experience of IBLI suggests that satellite indices have proved useful when assessing losses using standard ways is difficult, but this is possible only under proper design of indexes, understanding of farmers, and managing basis risk. PMFBY has shown that the delivery of crop insurance at a massive scale is possible, but its effectiveness is contingent on effective loss assessment, speedy claims resolution, and proper design of insurance products for farmers' needs. Technologies like YES-TECH, WINDS, and remote sensing can facilitate all these, but there is a need for reliable data, proper product design, farmer involvement, and institutional coordination. Thus, climate risk insurance should play the role of one

aspect of the integrated agricultural risk management approach along with other measures like resilient farming, credit, extension, irrigation, and agriculture infrastructure.

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Declaration of Conflicting Interests

The authors declare no conflict of interest.

Declaration of Generative AI and AI-assisted Technologies in the Writing Process

During the preparation of this manuscript, the authors have not used generative AI or AI-assisted technologies. The authors independently developed the conceptual framework and scholarly arguments and remain fully responsible for the accuracy, originality, and integrity of the manuscript.

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