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Landholding size, indebtedness, and crop insurance in India: A macro-level quantitative assessment

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Abstract. *Keerthikumara SM, Saikia B, Hiremath C. 2025. Landholding size, indebtedness, and crop insurance in India: A macro-level quantitative assessment. Asian J Agric 9: 377-390.* Indian farmers continue to face structural distress driven by low income, high indebtedness, and inadequate risk protection. This study investigates the interrelationship between landholding size, agricultural credit, indebtedness, and crop insurance uptake using state-level secondary data from 2016 to 2023, drawn from Agricultural Statistics at a Glance, PMFBY/RWBCIS dashboards, and NCRB reports. Using descriptive statistics, linear regression, and paired t-tests, we identify key macro-level trends across 20 major Indian states. Results show that marginal and small farmers (less than 2 hectares) account for over 62.7% of all indebted farm households, but receive only 38.5% of total institutional agricultural credit. A bivariate regression reveals that a ₹1,000 increase in monthly farm income is associated with a reduction of 1,314 indebted households (β=-0.445, p=0.016). Despite substantial credit disbursal in high-debt states like Andhra Pradesh and Telangana, farmer debt remains elevated, underscoring that credit alone does not reduce vulnerability. Crop insurance enrollment increased after the 2020 policy shift from mandatory to optional participation among loanee farmers, yet the change was not statistically significant (p=0.099). Actuarial analysis reveals that in several states, claim settlement ratios remain below 50%, with high premiums and delayed payouts fueling distrust. The study recommends fully subsidized premiums for marginal farmers, region-specific pricing, improved claim transparency, and financial literacy integration with agricultural extension. Effective risk mitigation in agriculture must go beyond insurance and integrate income and credit reforms to ensure equitable protection for India's most vulnerable farmers.

Keywords: Actuarial performance, crop insurance, farmer indebtedness, landholding size, regression analysis

INTRODUCTION

The Indian farming sector is highly vulnerable to adverse rainfall, climatic aberrations, and natural calamities, resulting in crop failures, indebtedness, suicides, and migration. Farming outcomes depend heavily on weather and market dynamics, with farmers exposed to both yield and price risks. Unpredictable rainfall is a major source of yield risk, disrupting the supply–demand balance and causing price volatility (Gulati et al. 2018). These production risks reduce agricultural output, hinder economic growth, and perpetuate poverty (Amare and Balana 2023). Nearly one-third of agricultural households face yield risks (Birthal et al. 2019). In the past decade, extreme temperature and rainfall variability lowered yields by 4.35% and 9.75%, respectively (GoI 2018). Climate change is projected to reduce incomes by 15-18% in irrigated and 20-25% in unirrigated areas, where almost half of principal crop land remains unirrigated (GoI 2018; GoI 2023).

Governments have attempted to mitigate agricultural risks through direct transfers and loan waivers, but these measures are often temporary and counterproductive (Narayanan and Mehrotra 2019). Indebtedness, driven by volatile incomes, crop failures, and rising cultivation costs, has become structural (Sidhu and Rampal 2016). Agrarian distress is increasingly evident in farmer suicides, with 38.5% of cases directly linked to indebtedness and bankruptcy (NCRB 2015). In response, the Government of India has launched programs such as the Pradhan Mantri Fasal Bima Yojana (PMFBY) and the Restructured Weather-Based Crop Insurance Scheme (RWBCIS) to protect farmers against yield loss and income instability. Although numerous studies have investigated crop insurance, credit distribution, and indebtedness separately, few have analyzed the structural interrelationship between these factors across states. This study seeks to address that gap at a macro-level perspective.

Landholding size, access to institutional credit, and crop insurance adoption are deeply interconnected. Larger farmers are more likely to secure loans due to higher collateral value (NABARD 2018), enabling them to afford premiums and adopt risk-reduction measures. In contrast, small and marginal farmers face limited credit availability, low financial literacy, and high transaction costs, which reduce participation in insurance (Dey and Maitra 2017; Biswal and Bahinipati 2022). Since credit-linked schemes such as PMFBY primarily cover loanee farmers—often medium and large holders—many marginal farmers remain excluded. While credit can reduce production risks and improve productivity (Yadav and Rao 2022), it also increases financial exposure, making insurance essential. Indebtedness can either drive farmers to seek insurance or discourage

them due to high premiums, lack of trust, and delays in claim settlement, producing state-level disparities.

India's crop insurance sector has undergone significant policy changes in recent years. The PMFBY, launched in 2016 to replace earlier schemes, sought to expand coverage, lower premiums, and ensure timely settlement of claims. Initially, enrollment was mandatory for loanee farmers, thereby linking insurance directly to institutional credit. A major reform in 2020 made enrollment voluntary for all farmers, including those accessing credit. Subsequently, several states, including West Bengal and Andhra Pradesh, withdrew from the central scheme and introduced their own versions. This evolving policy landscape is essential for interpreting patterns of insurance adoption and indebtedness between 2018 and 2021. Despite the critical importance of these reforms, only limited research has examined crop insurance, farm loans, and indebtedness together using national datasets.

Most existing studies focus on localized contexts or a single dimension, leaving major gaps in understanding how landholding size, credit, debt, and insurance interact across regions. This study analyzes data from 20 states between 2016 and 2022 to examine these structural connections. Two hypotheses are tested: (i) larger landholdings increase access to both institutional loans and crop insurance, and (ii) small and marginal farmers are less likely to participate in crop insurance because of restricted credit access. The central research question is: How are land size, institutional credit, indebtedness, and crop insurance uptake interrelated across Indian states?

The objectives of the study are: (i) to examine and compare the distribution of crop loans among states and across landholding size groups, and (ii) to assess the relationship between crop loan distribution, average monthly income, indebtedness, incidence of farmer suicides, and crop insurance adoption.

MATERIALS AND METHODS

Data and materials

This study is based entirely on secondary data collected from authentic and publicly accessible government sources. Data on crop loan disbursement, landholding patterns, and crop insurance performance were drawn from Agricultural Statistics at a Glance (ASG), published annually by the Directorate of Economics and Statistics, Ministry of Agriculture and Farmers Welfare, Government of India, for the period 2016-2017 to 2022-2023. Data on farmer suicides were obtained from the Accidental Deaths and Suicides in India (ADSI) reports published by the National Crime Records Bureau (NCRB), Ministry of Home Affairs, for the years 2016 to 2021. Additional crop insurance data, including premium and claim statistics, were sourced from the official portals of the Pradhan Mantri Fasal Bima Yojana (PMFBY) and the Restructured Weather-Based Crop Insurance Scheme (RWBCIS). The analysis focused on 20 major agricultural states in India, selected based on the volume of institutional agricultural credit and crop insurance coverage. All variables used were state-level aggregates, and their definitions and units of measurement are provided in the appendix. The dataset includes annual state-wise observations, forming a structured panel where applicable.

In this study, "indebtedness" refers to the proportion of agricultural households reporting outstanding debt, based on state-level survey data. The measure includes both formal (institutional) and informal (non-institutional) sources, but the dataset does not distinguish between productive vs. consumptive, or short- vs. long-term loans. As such, we treat indebtedness as a composite indicator of financial vulnerability. We acknowledge that different debt types may have varying implications for insurance uptake, and we recommend that future studies explore this distinction using disaggregated micro-level data.

Analytical tools

To meet the first objective, we use descriptive statistics to study how crop loans are distributed across different landholding groups and Indian states. This study uses state-level secondary data from official government sources: (i) Agricultural Statistics at a Glance (2016-2023) for credit and landholding data, (ii) PMFBY/RWBCIS dashboards (2018-2023) for insurance coverage and performance, and (iii) NCRB's ADSI reports (2016-2021) for farmer suicides. The dataset includes annual observations from 20 major agricultural states. As administrative aggregates, these data are not sample-based and thus do not include household-level sampling metadata. A separate table of descriptive statistics was not included to avoid duplication, as key descriptive patterns are already presented in the detailed result tables.

To see whether loanee farmers' participation in crop insurance changed after the 2020 policy shift—from mandatory to voluntary—we apply a paired t-test. This compares average enrollment in the years before the change (2018-2019) with the years after (2020-2021). However, since the number of data points is small (N=4), the test has low statistical power. So, we treat the results as exploratory. We also look at yearly trends using descriptive comparisons instead of relying only on the test results.

To address the second objective, we use a simple cross-sectional regression model. It examines the relationship between average farm income and farmer indebtedness across 20 states. Due to data limitations, we cannot include other important factors like land size, credit access, crop type, or rainfall. So, this model focuses only on the link between income and debt. The findings should not be seen as causal, but rather as early evidence pointing to a possible relationship. We test the model's assumptions. The Shapiro-Wilk test shows that the residuals are normally distributed. Variance Inflation Factors (VIFs) are below 2.0, which means there's no problem with multicollinearity. We also check for heteroskedasticity using residual plots and find no major issues. The regression includes standard errors, R^2 values, and 95% confidence intervals. Still, we note that using a bivariate model with limited data is a constraint, and future research should use more detailed datasets and include additional control variables. Robustness checks, such as multivariate or panel regressions, are not

applied due to data constraints but are recommended for future studies.

To evaluate the performance of crop insurance schemes, the following standard actuarial indicators were calculated:

$$Acturial\ Premium\ Rate = \frac{Gross\ premium}{Sum\ insured} \times 100$$

$$Loss\ Reduction = \frac{Claims\ paid}{Sum\ insured} \times 100$$

$$Cost - Benefit = \frac{Claims\ paid}{Gross\ premium} \times 100$$

All calculations were based on state-wise aggregates reported in the PMFBY and RWBCIS dashboards. Cases of missing data were excluded from the final analysis. No formal ethical approval was needed, as per institutional and academic guidelines for research not involving human subjects. The list of all variables is shown in Table 1.

RESULTS AND DISCUSSION

Crop loan disbursement patterns

Tamil Nadu, Andhra Pradesh, Rajasthan, Uttar Pradesh, Kerala, Punjab, Gujarat, Karnataka, Madhya Pradesh, and Maharashtra have allocated the highest amount of crop loans in comparison to the remaining states in India. According to Yadav and Rao (2022), agricultural credits positively influence crop productivity. The states contributed to the production of food grains in India, with percentages of 3.82%, 3.57%, 6.67%, 17.77%, 0.20%, 8.94%, 3.19%, 4.37%, 12.37%, and 5.43% respectively. Tamil Nadu, Andhra Pradesh, Kerala, Gujarat, Karnataka, and Maharashtra have been identified as regions with relatively lower productivity despite their pioneering role in the consumption of crop loans. This may result from yield loss due to the lack of irrigation infrastructure and weather aberrations (Table 2).

In practical terms, this implies that for every ₹1,000 increase in average monthly income, the proportion of indebted farm households could be expected to decrease by approximately 1314, assuming other factors remain constant. States like Andhra Pradesh and Telangana have high loan disbursal but still high debt, suggesting farm income isn't enough to reduce debt. In contrast, states like Punjab and Meghalaya, with higher incomes, show lower debt, meaning their farm income likely covers costs better. Overall, higher income seems to reduce the need for loans. This pattern emphasizes the importance of policies aimed at enhancing agricultural income, such as improving market access, investing in agricultural technology, and providing better farming inputs, which could help reduce the reliance on loans and lower the indebtedness among farmers. The interplay between loan distribution and income in these states brings to light the critical role of financial management and income augmentation in agricultural policy planning. It suggests that while loans are essential for supporting agricultural operations, equal emphasis needs to be placed on strategies that enhance income generation from farming to create a sustainable agrarian economy (Table 3, Figure 1).

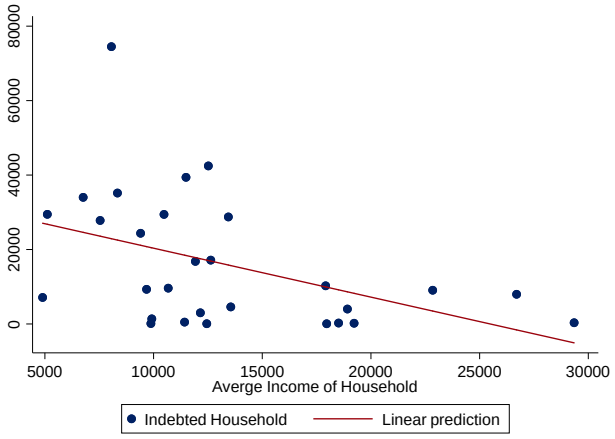

Figure 1. Relationship between average monthly farm income and percentage of indebted agricultural households across 20 Indian states. The fitted line represents a bivariate linear regression (R^2=0.40, p=0.016), indicating a negative association between income and indebtedness, derived from linear regression (Table 3).

Table 1. Description of variables

Variable name	Definition/description	Type	Unit of measurement
Indebtedness (%)	Percentage of agricultural households with outstanding institutional loans	Continuous	Percent (%)
Average outstanding loan	Average debt per indebted agricultural household	Continuous	Indian Rupees (₹)
Landholding size category	Classification of farmers based on owned land: Marginal (<1 ha), Small (1-2 ha), etc.	Categorical	Hectares (ha)
Crop loan disbursement	Total institutional short-term crop loans distributed to agricultural households	Continuous	Indian Rupees (Lakh ₹)
Average monthly income	Average monthly income per agricultural household by state	Continuous	Indian Rupees (₹)
Insurance coverage	Number of farmers enrolled under PMFBY/RWBCIS schemes	Continuous	No. of farmers (in Lakhs)
Loanee farmers (%)	Proportion of insured farmers who had taken institutional loans	Continuous	Percent (%)
Non-loanee farmers (%)	Proportion of insured farmers not linked to loans	Continuous	Percent (%)
Area insured	Total agricultural land area covered under insurance schemes	Continuous	Lakh hectares
Gross premium	Total premium collected under PMFBY/RWBCIS	Continuous	Indian Rupees (Crore ₹)
Claims paid	Total claims disbursed to insured farmers under PMFBY/RWBCIS	Continuous	Indian Rupees (Crore ₹)
Farmer suicides	Number of reported suicides by cultivators	Continuous	Number of cases

Table 2. Total state-wise crop loans distributed to agricultural households from 2016-2017 to 2022-2023

State	Crop loan (Amount in Lakh)	Ranks
Andaman & Nicobar	46214.22	34
Andhra Pradesh	47009918	2
Arunachal Pradesh	59089.58	31
Assam	820477.2	23
Bihar	8283101	14
Chandigarh	319753.6	25
Chhattisgarh	5697957	16
Dadra & Nagar Haveli	14691.94	37
Daman & Diu	155598.7	29
Delhi	2109709	20
Goa	243311.5	26
Gujarat	27152267	7
Haryana	22545583	11
Himachal Pradesh	3620265	18
Jammu & Kashmir	4875560	17
Jharkhand	1320456	21
Karnataka	26551997	8
Kerala	30554252	5
Lakshadweep	342212.9	24
Madhya Pradesh	25065910	9
Maharashtra	22936679	10
Manipur	31513.12	35
Meghalaya	111695.9	30
Mizoram	16280.96	36
Nagaland	55874.34	32
Odisha	9428210	13
Puducherry	1289989	22
Punjab	29005625	6
Rajasthan	40330071	3
Sikkim	52022.66	33
Tamil Nadu	67089824	1
Telangana	22475593	12
Tripura	216064.6	28
Uttarakhand	2704249	19
Uttar Pradesh	39249562	4
West Bengal	7549601	15
Ladakh	224372	27

Source: ASG Reports 2016-2017 to 2022-2023

Marginal and small farmers mostly take short- and medium-term loans to meet urgent farming needs like seeds, fertilizers, and labor, due to limited income and working capital. They rarely go for long-term loans as they can't afford big investments. Medium and large farmers, with more land and resources, take long-term loans for things like irrigation, machinery, and land development. Most loans go to small farmers since they make up the majority of India's farming community. As land size increases, the share of long-term loans rises, but total loan numbers drop, likely due to fewer big farmers or their better financial stability. This shows the need for credit schemes suited to different farm sizes to support both short-term needs and long-term growth in agriculture (Bathla and Hussain 2022) (Table 4).

Farmer indebtedness and income

The state-wise data on farm households reveals significant regional disparities in indebtedness, loan dependence, and income levels. Andhra Pradesh stands out for its high levels of farm indebtedness despite only moderate incomes, indicating financial stress and reliance on credit for survival rather than investment. In contrast, states like Meghalaya and Punjab display stronger farm economies—low debt levels paired with high average monthly incomes—suggesting more sustainable agricultural practices and better market access (Chand et al. 2015). Meghalaya, in particular, has the lowest indebtedness and the highest income among agricultural households, possibly reflecting reduced reliance on external financing and more diversified or efficient farming systems. Kerala and Tamil Nadu also show high indebtedness, but unlike Andhra Pradesh, they maintain relatively higher incomes. This may indicate more productive use of loans, potentially for high-value crops or improved technologies. On the other hand, Bihar and Uttar Pradesh, with large agricultural populations, show low incomes and moderate to high debt, pointing to persistent issues in productivity, infrastructure, and financial inclusion. Smaller states and union territories such as Mizoram and Nagaland exhibit both low indebtedness and low incomes, which may reflect limited integration into commercial agriculture and lower access to formal credit systems. These patterns emphasize the uneven distribution of credit, income, and financial stress across India's agricultural landscape, shaped by regional policy frameworks, economic structures, and the effectiveness of financial and agricultural support systems. Addressing these disparities is crucial for fostering inclusive growth and ensuring that financial interventions translate into real improvements in farmers' livelihoods (Das et al. 2025) (Table 5).

Table 3. Linear regression results

Model		Coefficients			t	Sig.
		Unstandardized coefficients		Standardized coefficients		
		B	Std. Error	Beta		
1	(Constant)	33498.123	7378.096		4.540	.000
	Income	-1.314	.509	-.445	-2.581	.016

Note: Dependent Variable: Indebted Households. B: Unstandardized coefficient, Beta: Standardized coefficient, Sig.: significance level

Table 4. Total short-term institutional credit obtained for agricultural purposes by various size-groups in India

Land holding (Ha)	Short-term loans (%)	Medium-term loans (%)	Long-term loans (%)	Total (%)
Marginal (below 1.00)	40.49	35.08	27.00	38.49
Small (1.0-1.99)	24.71	25.25	21.29	24.60
Semi-Medium (2.0-3.99)	19.65	21.37	24.88	20.34
Medium (4.0-9.99)	12.54	15.42	21.09	13.69
Large (10 & above)	2.62	2.87	5.74	2.88
All Groups	100.00	100.00	100.00	100.00

Source: ASG Report 2022. Note: While Tables 3 and 5 both categorize farmers by landholding size, they reflect different dimensions—loan disbursement (Table 4) and debt incidence (Table 6)—and are retained separately for clarity

Table 5. State-wise estimated agricultural households, indebted agricultural households, and average monthly income

States	Estimated number of agricultural households ('00)	Estimated number of agricultural households with loans ('00)	Agricultural households indebted (%)	Indebted rank	Average monthly income per agricultural household (Rs)	Income rank
Andhra Pradesh	31587	29430	93.2	1	10480	19
Arunachal Pradesh	1524	191	12.5	25	19225	4
Assam	30999	9617	31	20	10675	18
Bihar	70123	27804	39.7	17	7542	26
Chhattisgarh	29851	9307	31.2	19	9677	22
Gujarat	40369	17147	42.5	15	12631	11
Haryana	19062	9061	47.5	13	22841	3
Himachal Pradesh	10280	3005	29.2	21	12153	14
Jammu & Kashmir	12557	4011	31.9	18	18918	5
Jharkhand	28080	7116	25.3	23	4895	29
Karnataka	42501	28748	67.6	4	13441	10
Kerala	14667	10257	69.9	3	17915	8
Madhya Pradesh	72738	35173	48.4	11	8339	24
Maharashtra	72941	39390	54	9	11492	16
Manipur	2412	497	20.6	24	11427	17
Meghalaya	3647	333	9.1	27	29348	1
Mizoram	764	61	8	28	17964	7
Nagaland	1918	116	6	29	9877	21
Odisha	48153	29452	61.2	6	5112	28
Punjab	14671	7976	54.4	8	26701	2
Rajasthan	70378	42455	60.3	7	12520	12
Sikkim	652	69	10.6	26	12447	13
Tamil Nadu	25825	16813	65.1	5	11924	15
Telangana	26557	24363	91.7	2	9403	23
Tripura	2893	1380	47.7	12	9918	20
Uttarakhand	9844	4585	46.6	14	13552	9
Uttar Pradesh	177583	74493	41.9	16	8061	25
West Bengal	66890	34012	50.8	10	6762	27
UTs	897	247	27.5	22	18511	6
All India	930935	467196	50.2		10218	

Source: ASG Report 2022

Table 6. All-India indebted agricultural households by land size and average outstanding loan

Land owned (hectare)	Estimated number of agricultural families (Lakh)	Estimated number of indebted agricultural families (Lakh)	Indebted agricultural families (%)	Average outstanding loan amount (Rs)
<0.01	5.70	2.20	38.60	26883
0.01-0.40	318.61	130.03	40.81	33220
0.41-1.00	331.48	160.57	48.44	51933
1.01-2.00	164.83	94.56	57.37	94498
2.01-4.00	80.37	56.01	69.69	175009
4.01-10.00	26.46	20.97	79.25	326766
10 & above	3.49	2.84	81.38	791132
All India	930.94	467.20	50.19	74121

Source: ASG Report 2022

Loan size and landholding analysis

In India, small and marginal farmers with less than 2 hectares of land form most of the farming population and indebted households. They mainly rely on short-term loans to cover seasonal farming costs like seeds, fertilizers, and labor. The reliance on short-term borrowing reflects both the urgent nature of their financial needs and their limited access to longer-term credit products. Most marginal farmers lack formal collateral, credit history, or financial literacy, which makes them less eligible for long-duration loans that could help build productive assets or improve farm infrastructure (Table 6).

Medium and large farmers—those with over 4 hectares —generally have better access to long-term institutional credit, which they use for capital investments like machinery, irrigation, and land improvement. These farmers, though fewer in number, receive a disproportionate share of long-term loans due to better financial literacy, collateral, and institutional linkages. They borrow more but also have greater repayment capacity. In contrast, marginal farmers often take smaller loans for short-term needs and remain financially vulnerable due to low incomes and limited insurance coverage. Many smallholders avoid insurance altogether due to low awareness, poor cash flow, and ill-suited schemes. This disparity in access to credit and insurance has serious policy implications. While large farmers leverage formal credit to modernize and expand, small and marginal farmers often rely on it merely to sustain seasonal farming. Without adequate risk protection, they are more likely to fall into debt traps. Thus, even though institutional credit is crucial across the board, its unequal distribution reinforces rural inequality and undermines the resilience of smallholders. Addressing this imbalance is key to making rural financial systems more inclusive and equitable (Table 6).

Marginal and small farmers not only rely more heavily on short-term loans but also face greater risks due to limited access to insurance and capital. In contrast, larger farmers are better positioned to access a mix of credit products and manage agricultural risk more effectively. These differences call for differentiated credit and insurance policies—ones that go beyond one-size-fits-all approaches and instead cater to the diverse realities of Indian farmers.

West Bengal has the highest number of marginally indebted agricultural households, followed by Bihar, Uttar Pradesh, Odisha, and Andhra Pradesh, among the major states. Our observations indicate that the prevalence of medium- and large-indebted agricultural households in the states is extremely low, at zero percent. Indebted small farmers are more prevalent in Telangana, Maharashtra, Madhya Pradesh, Karnataka, and Rajasthan than in all other major states. Andhra Pradesh has more large indebted agricultural households, followed by Punjab and Rajasthan. Table 7 reveals that Maharashtra has the most significant proportion of farmer suicides, followed by Karnataka, Andhra Pradesh, Madhya Pradesh, and Telangana, accounting for 37.44%, 20.27%, 8.12%, 7.13%, and 6.93% at the national level, respectively. Indebtedness is one of the significant reasons behind farmer suicides, especially among marginal and small farmers (Sukhpal Singh et al. 2014; Macharla 2015; Dandekar and Bhattacharya 2017) (Table 7).

Farmer suicides and insurance adoption

A few states in western and southern India report the highest numbers of farmer suicides. These areas often have intense farming activity, large loan disbursements, and high debt levels. While this suggests a link between financial pressure and farmer distress, it does not prove that debt alone causes suicides. Farmer suicides are the result of many overlapping problems—such as crop failure, income loss, poor irrigation, sudden weather events, and lack of support services. Many affected farmers may also struggle with delayed insurance payouts and low crop prices. However, existing data does not tell us whether the farmers who died by suicide had loans or insurance, or what personal or emotional challenges they faced. To truly understand why these tragedies happen, we need detailed, ground-level studies. These should look at personal factors like land size, debt type, losses, family responsibilities, and mental health. Only then can we design policies that protect farmers not just financially, but emotionally and socially as well (Table 8).

Table 7. Percentage of indebted agricultural families by land size in selected states

States	Marginal indebted agricultural households (%)	Small indebted agricultural households (%)	Semi-medium indebted agricultural households (%)	Medium indebted agricultural households (%)	Large indebted agricultural households (%)
	(up to 1.0 ha)	(1.01 to 2 ha)	(2.01 to 4 ha)	(4.01 to 10 ha)	(>10.00 ha)
Uttar Pradesh	77.5	13.9	6.6	1.9	0.1
Maharashtra	40.3	30.3	20.2	8.2	1.1
Madhya Pradesh	45	27.9	17.5	8.8	0.9
Rajasthan	47.1	24.8	17.2	9.8	1.2
Karnataka	47.9	26.2	18.1	7.2	0.5
Andhra Pradesh	52.1	24.5	18.1	3.6	1.6
Telangana	40.3	30.9	21.5	6.9	0.5
Bihar	83.8	11.7	4.1	0.2	0.2
West Bengal	93.8	5.1	1	0.1	0
Punjab	47.8	18.6	18.6	13.6	1.4
Odisha	72.7	20	6.1	1.1	0.1
All India	62.7	20.2	12	4.5	0.6

Source: ASG Report 2022

The dataset tracks the number of loanee farmers who purchased crop insurance across two main agricultural seasons—Kharif and Rabi—over several years, specifically highlighting the impact of a policy intervention that shifted crop insurance from mandatory to optional. Initially, when the purchase of crop insurance was compulsory, the number of insured loanee farmers was substantial but showed a moderate increase from one year to the next. When insurance was mandatory with loans, farmers complied. After it became optional, more farmers chose it, especially during Kharif 2022, likely due to rising risk awareness. But in 2023, numbers dropped—possibly due to economic stress, changing farm practices, or doubts about insurance value. Notably, data for the Rabi season 2023 is missing, which could also affect the interpretation of trends for that year. The transition from mandatory to optional insurance purchase has initially encouraged more farmers to voluntarily engage with crop insurance schemes, suggesting that the farmers see value in the insurance beyond mere compliance with loan requirements. This shift emphasizes the importance of designing policy interventions that not only mandate protection but also build trust and perceived value in such protections, encouraging voluntary participation that sustains beyond the period of mandatory enforcement (Tables 8 and 9).

Insurance performance evaluation

A smaller proportion of marginal farmers opt for crop insurance compared to small, medium, and large farmers, mainly due to liquidity constraints and limited capacity to afford premiums (Dey and Maitra 2017; Biswal and Bahinipati 2022). Loanee farmers show higher participation rates, largely because insurance was mandatory for them until Kharif 2020 (ADRTC 2019). However, contrary to earlier assumptions, recent evidence suggests that loanee farmers voluntarily continue to choose insurance even after the mandate, indicating a risk-averse outlook and growing trust in insurance as a safety tool. At the same time, the persistently high rates of farmer suicides in specific states reflect deep regional disparities in agrarian distress, driven by debt, crop failures, and lack of market and institutional support. While insurance schemes like PMFBY and RWBCIS are designed to cushion such risks, uptake varies significantly across landholding categories. Small farmers tend to insure more than marginal or large farmers, likely due to differences in risk perception, access, and awareness. This uneven coverage underscores a critical gap: while crop insurance is meant to reduce vulnerability, it still falls short in reaching and benefiting the most at-risk groups. A stronger impact requires not just wider insurance access, but also reforms that tackle underlying structural challenges in agriculture, ensuring a more comprehensive safety net for India's farming community (Table 10).

Most of the farmers covered under schemes like PMFBY and RWBCIS are those who have taken loans, as insurance is often linked to credit. Over the years, insurance coverage among these loanee farmers has increased, especially during the Kharif season. In contrast, fewer non-loanee farmers—those without formal loans—are buying insurance on their own. This shows that many farmers rely on institutional credit to access insurance. As a result, those who don't take loans are often left out and remain unprotected against crop loss or natural disasters. This gap highlights the need for better support for non-loanee farmers, so that all farmers, regardless of their credit status, can access insurance and reduce their risks (Table 11).

The data shows that after a policy change, the average number of insured farmers rose, but with more variation across regions. Before the change, insurance numbers were lower but more consistent. The rise in both the mean and variability suggests the policy boosted insurance uptake, though unevenly. This points to the need for more targeted efforts to ensure broader and fairer coverage among all farmers (Table 12).

Table 8. Percentage distribution of farmer's (cultivators) suicides in the top ten states combined from 2016-2021

States	Number of farmers' suicides	Percentage
Maharashtra	20090	37.44
Karnataka	10878	20.27
Andhra Pradesh	4358	8.12
Madhya Pradesh	3824	7.13
Telangana	3721	6.93
Chhattisgarh	2448	4.56
Tamil Nadu	1737	3.24
Punjab	1541	2.87
Kerala	1072	2.00
Uttar Pradesh	1002	1.87
All India	53660	100.00

Source: ADSI, NCRB Reports

Table 9. Number of loanee farmers purchased crop insurance before and after the policy intervention

Purchase option	Year	Season		Total
		Kharif	Rabi	
Mandatory	2018	20470212	13368281	33838493
	2019	23809296	13133651	36942947
Optional	2020	27005500	12387563	39393063
	2021	37371384	24167866	61539250
	2022	53060910	34320151	87381061
	2023	37673524	NA	37673524
Total		199390826	97377512	296768338

Source: pmfby.gov.in

Table 10. PMFBY and RWBCIS-insured farmers in different land sizes across India

Year	Marginal farmers (%)		Small farmers (%)		Medium and large farmers (%)	
	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi
2018	18.07	19.18	64.86	63.01	17.07	17.81
2019	16.47	18.4	67.62	60.86	15.91	20.74
2020	16.54	17.39	67.64	64.54	15.82	18.08
2021	18.03	18.2	62.18	60.76	19.79	21.04
2022	15.1	15.95	66.03	63.81	18.87	20.24

Source: pmfby.gov.in

Table 11. Types of insured farmers under PMFBY and RWBCIS

Farmers type	Season	2018 (%)	2019 (%)	2020 (%)	2021 (%)	2022 (%)	2023 (%)	Total (%)
Loanee farmers	Kharif	63.96	58.57	65.39	75.09	78.40	60.08	69.89
	Rabi	58.69	71.35	61.26	73.49	80.95	NA	71.24
Non-loanee farmers	Kharif	36.04	41.43	34.61	24.91	21.60	30.92	30.11
	Rabi	41.31	28.65	38.74	26.51	19.05	NA	28.76

Source: pmfby.gov.in

Table 12. Paired samples statistics for loanee and non-loanee farmers

Particulars	Mean	N	Standard Deviation	Standard error mean
Before	17695360.00	4	5310769.521	2655384.760
After	25233078.25	4	10273296.850	5136648.425

Source: Authors' calculations

The paired samples t-test evaluates whether the number of insured farmers—both loanee and non-loanee—significantly changed before and after the policy shift that made insurance enrollment optional in Kharif 2020. The results show a negative mean difference, indicating that, on average, more farmers were insured after the policy change than before. However, this difference is not statistically significant. The p-value (0.099) exceeds the standard threshold of 0.05, and the 95% confidence interval includes zero, indicating that the observed change may be due to random variation rather than the policy intervention itself. The relatively high standard deviation also points to variability across states or regions. Therefore, while the descriptive trend suggests an increase in uptake, the statistical evidence is insufficient to attribute this to the policy shift with confidence. This reinforces the importance of using larger sample sizes and more granular, farm-level data in future evaluations of crop insurance policy impacts (Table 13).

At first glance, crop insurance in India appears to be a success, with states like Maharashtra, Madhya Pradesh, Rajasthan, and Karnataka showing high enrolment, extensive coverage, and substantial claim payouts. These figures suggest the schemes are effectively targeting high-risk agricultural zones. However, a closer look reveals stark disparities. Smaller and remote states—particularly in the Northeast like Arunachal Pradesh and Meghalaya, as well as Union Territories like Goa and Puducherry—show minimal coverage and negligible claims, indicating weak integration into the insurance framework (Thangjam et al. 2018). This uneven implementation likely stems from low awareness, institutional gaps, and logistical barriers. Moreover, in some states, premiums collected far exceed the claims paid, fueling discontent among small and marginal farmers. For them, insurance often feels like an added burden rather than a safety net, especially when payouts are delayed or denied. While crop insurance has expanded, its benefits remain uneven. A more equitable and responsive system is needed—one that prioritizes timely claims, simplifies procedures, and reaches underserved regions with better support mechanisms (Ahmed and Shakoor 2025) (Table 14).

A key concern with crop insurance in India is the disparity in insured area and sum insured per farmer across states. In regions with smaller insured areas or lower sums, compensation often falls short of covering actual losses, especially for smallholders (Kaur et al. 2021). Conversely, states with higher coverage tend to have more commercial farming and institutional backing. Actuarial premium rates also vary significantly, with higher rates in climate-vulnerable regions like drought- or flood-prone areas. This makes insurance costly for small and marginal farmers, even with subsidies. In several states, low payouts compared to premiums have led to farmer distrust, especially when delays, rejections, and poor service persist (Akber et al. 2023). While insurers may profit, many farmers remain inadequately protected. Thus, there's a pressing need to realign insurance policies to ensure timely claims, transparent processes, and affordable, equitable premiums that truly serve the farming community—not just insurance companies (Kumari and Kumari 2025) (Table 15).

Table 13. Paired samples T-test for loanee and non-loanee farmers

	Paired differences					t	df	Sig. (2-tailed)
	Mean	Standard Deviation	Standard error mean	95% Confidence interval				
				Lower	Upper			
Before - After	-7537718.250	6379319.268	3189659.634	-17688638.767	2613202.267	-2.363	3	.099

Table 14. Progress across states under PMFBY and RWBCIS from 2016-2017 to 2022-2023

States	Number of farmers insured (in (Lakhs)	Area insured (in Lakh hectares)	Sum insured (in Crore)	Gross premium (in Crore)	Claims paid (in Crore)
A & N Islands	0.02	0.02	8.04	0.7	0.23
Andhra Pradesh	88.41	76.85	49159.94	4988.37	4828.12
Assam	41.64	25.45	17402.92	705.08	210.82
Bihar	50.17	46.09	21749.1	2444.86	749.37
Chhattisgarh	272.35	163.83	59475.12	7328.15	6220.91
Goa	0.03	0.01	14.73	0.21	0.14
Gujarat	83.95	112.33	53812.1	12045.28	5232.62
Haryana	101.14	130.58	87252.65	6584.35	5891.26
Himachal Pradesh	19.87	77.06	4526.81	543.61	291.25
Jammu & Kashmir	4.54	3.25	2031.93	181.14	87.98
Jharkhand	44.62	19.4	10733.48	1236.76	98.08
Karnataka	148.54	138.82	63746.41	14117.05	10123.08
Kerala	4.94	3.08	2283.08	421.5	333.86
Madhya Pradesh	573.8	782.35	275284.61	34625.68	25674.12
Maharashtra	841.83	485.73	187318.78	38385.61	25849.84
Manipur	0.28	0.36	142.4	10.01	5.24
Meghalaya	0.05	0.03	26.37	0.99	0.51
Odisha	364.96	91.67	57068.43	8654.03	6150.04
Puducherry	0.84	0.49	307.7	22.31	15.68
Rajasthan	1086.09	683.19	220272.99	31356.04	20403.66
Sikkim	0.05	0.01	8.17	0.24	0.67
Tamil Nadu	238.6	96.19	58874.52	14129.42	12699.81
Telangana	36.36	37.83	25529.7	2222.2	1811.67
Tripura	8.94	1.48	1014.55	29.75	5.13
Uttar Pradesh	350.88	283.56	135337.93	9614.65	4060.1
Uttarakhand	14.76	55.31	5904.94	791.5	487.54
West Bengal	134.91	55.85	37345.91	2086.77	1218.52
Grand Total	4512.57	3370.79	1376633.3	192526.25	132450.3

Source: ASG Reports 2022

Discussion

Credit–income dynamics and policy intersections

This study reaffirms a significant inverse relationship between agricultural income and indebtedness. States like Punjab and Haryana, where farm incomes are higher, report lower indebtedness levels. This supports the assertion that agricultural credit, when not accompanied by stable income streams, may exacerbate financial vulnerability. Conversely, states like Andhra Pradesh and Telangana demonstrate how extensive credit disbursement without corresponding income growth fails to resolve underlying debt burdens. Therefore, policies must integrate credit access with income-enhancing strategies such as price stabilization, infrastructure development, and direct income transfers. Empirical evidence from other South Asian countries, notably Bangladesh and Nepal, emphasizes the efficacy of guaranteed procurement and public support systems in mitigating farm debt and improving resilience (Volkov et al. 2025).

Structural inequality in credit and land reforms

Credit distribution in India remains skewed toward medium and large farmers who possess greater collateral and financial literacy. Small and marginal farmers predominantly access short-term loans, limiting their capacity to invest in capital improvements or diversify risk. This systemic bias is not unique to India but is evident across South Asia. In Pakistan and Sri Lanka, institutional finance is similarly concentrated among larger agrarian stakeholders (Khan et al. 2025). Without simultaneous reforms in land tenure and institutional access, financial inclusion remains exclusionary. A renewed focus on tenancy rights, formal land titles, and community-based lending models like SHGs and FPOs is essential. These structural changes can democratize access to long-term credit and mitigate the disparities entrenched in rural financial systems.

Table 15. State-wise performance of PMFBY and RWBCIS from 2016-2017 to 2022-2023

States	Average area insured per farmer (hectares)	Average sum insured per insured area	Actuarial premium rate (%)	Loss reduction (%)	Cost-benefit (%)	Profit to companies (in Crore)
A & N Islands	1.00	40200.00	8.71	2.86	32.86	0.47
Andhra Pradesh	0.87	63968.69	10.15	9.82	96.79	160.25
Assam	0.61	68380.83	4.05	1.21	29.90	494.26
Bihar	0.92	47188.33	11.24	3.45	30.65	1695.49
Chhattisgarh	0.60	36302.95	12.32	10.46	84.89	1107.24
Goa	0.33	147300.00	1.43	0.95	66.67	0.07
Gujarat	1.34	47905.37	22.38	9.72	43.44	6812.66
Haryana	1.29	66819.31	7.55	6.75	89.47	693.09
Himachal Pradesh	3.88	5874.40	12.01	6.43	53.58	252.36
Jammu & Kashmir	0.72	62520.92	8.91	4.33	48.57	93.16
Jharkhand	0.43	55327.22	11.52	0.91	7.93	1138.68
Karnataka	0.93	45920.19	22.15	15.88	71.71	3993.97
Kerala	0.62	74125.97	18.46	14.62	79.21	87.64
Madhya Pradesh	1.36	35186.89	12.58	9.33	74.15	8951.56
Maharashtra	0.58	38564.38	20.49	13.80	67.34	12535.77
Manipur	1.29	39555.56	7.03	3.68	52.35	4.77
Meghalaya	0.60	87900.00	3.75	1.93	51.52	0.48
Odisha	0.25	62254.21	15.16	10.78	71.07	2503.99
Puducherry	0.58	62795.92	7.25	5.10	70.28	6.63
Rajasthan	0.63	32241.83	14.24	9.26	65.07	10952.38
Sikkim	0.20	81700.00	2.94	8.20	279.17	-0.43
Tamil Nadu	0.40	61206.49	24.00	21.57	89.88	1429.61
Telangana	1.04	67485.33	8.70	7.10	81.53	410.53
Tripura	0.17	68550.68	2.93	0.51	17.24	24.62
Uttar Pradesh	0.81	47728.15	7.10	3.00	42.23	5554.55
Uttarakhand	3.75	10676.08	13.40	8.26	61.60	303.96
West Bengal	0.41	66868.24	5.59	3.26	58.39	868.25
Grand Total	0.75	40840.08	13.99	9.62	68.80	60076.01

Insurance trust deficit and subsidy targeting

While the Pradhan Mantri Fasal Bima Yojana (PMFBY) and RWBCIS have expanded in coverage, their implementation has suffered from a trust deficit, especially among non-loanee and marginal farmers. Insurance adoption remains higher among loanee farmers due to automatic enrollment, while voluntary participation is low due to poor awareness, perceived inefficiency, and high premium burdens. In high-risk states like Maharashtra and Odisha, this deterrence is particularly acute. Comparative research from Nepal and Bangladesh illustrates that decentralized, community-based crop insurance with flexible premiums and local grievance mechanisms ensures higher uptake and satisfaction. To enhance PMFBY's effectiveness, India should consider differentiated premium structures by agro-climatic zones and deploy automated, technology-based claim assessments. Grievance redressal mechanisms must be decentralized and farmer-centric (Cariappa et al. 2021; Biswal and Bahinipati 2022; Khan et al. 2024).

Farmer suicides and the policy vacuum

The persistent concentration of farmer suicides in high-debt states such as Maharashtra, Karnataka, and Madhya Pradesh reveals systemic distress aggravated by income volatility, rising input costs, and insurance inadequacies. Although causality is complex, a strong correlation exists between high indebtedness and suicide incidence (Dandekar and Bhattacharya 2017). Studies suggest that mental stress, social isolation, and the absence of institutional support are critical contributors (Macharla 2015). Despite PMFBY's aim to serve as a risk mitigation tool, long delays in claim settlement and poor coverage reduce its potential impact. India must adopt an integrated policy approach that combines financial instruments with rural mental health programs, legal support services, and tailored disaster relief mechanisms.

Comparative gaps and regional lessons in South Asia

India's crop insurance programs, particularly the Pradhan Mantri Fasal Bima Yojana (PMFBY), stand out in terms of their scale, public funding, and policy ambition. With tens of millions of farmers enrolled during peak implementation years, PMFBY has evolved into one of the largest agricultural insurance schemes globally. However, a closer look at the outcomes reveals persistent concerns—low claim settlement ratios, delayed payments, limited participation from non-loanee farmers, and growing mistrust in several states. These issues warrant a critical examination of alternative models from South Asia, many of which offer valuable lessons in institutional innovation, inclusivity, and responsiveness. In Bangladesh, crop insurance remains in an experimental stage but demonstrates considerable promise through its bottom-up, community-oriented delivery. Initiatives by organizations like BRAC and Syngenta

Foundation have piloted weather-index insurance schemes in flood-prone and drought-affected districts such as Sirajganj and Rajshahi. These rely on satellite data and rainfall thresholds to trigger automatic payouts, thereby avoiding the delays typically caused by post-disaster verification processes. Crucially, the involvement of local institutions—such as cooperatives, farmers' clubs, and microfinance agents—enhances both outreach and credibility. Where community-based actors facilitate enrollment and claims, uptake has been significantly higher, especially among women and landless farmers (Al-Maruf et al. 2021). Nepal provides a strong example of a public-private partnership model that places smallholder needs at its core. The government subsidizes up to 75% of insurance premiums, and the remaining share is often pooled through cooperatives or local institutions. Unlike India's centralized approach, Nepal's insurance programs are monitored by municipal and district-level agricultural bodies that work directly with farmers, insurers, and local administrations. This multi-stakeholder framework ensures faster claim processing and more transparent verification. Importantly, insurance awareness is embedded within agricultural extension programs, and mobile-based platforms are used to track claims and register grievances—fostering both accountability and trust (Budhathoki et al. 2019).

In Sri Lanka, the Agricultural and Agrarian Insurance Board (AAIB) manages a national-level insurance scheme that integrates crop coverage with broader social protection mechanisms. Beyond crop loss compensation, the AAIB offers livestock insurance, pension schemes, and disaster relief, creating a more comprehensive welfare structure for rural households. Its relatively high efficiency is attributed to the active role played by village-level officers, who are empowered to verify damages and facilitate claim assessments locally. Unlike India's system, which heavily depends on private insurers with limited field presence, Sri Lanka's model is publicly administered and thereby insulated from market-driven incentives that often discourage high-risk farmer enrollment. Turnaround times for claim settlement are shorter, typically within 30 to 60 days, and farmers report higher satisfaction levels (Rambukwella et al. 2018). In Pakistan, though insurance penetration remains low, recent programs have embraced digital innovations such as mobile-based enrollment, geo-tagging, and satellite imagery to reduce processing time and improve accuracy. Moreover, pilot programs have started experimenting with delinking insurance from agricultural credit, making it accessible to tenant and landless farmers—an area where India's PMFBY continues to underperform. Some initiatives are bundling insurance with climate advisory services, further enhancing risk preparedness (Qamer et al. 2023).

Across these cases, a few core insights emerge that are particularly relevant for India. First, participatory and decentralized governance models lead to higher program legitimacy. In Bangladesh and Nepal, the involvement of local cooperatives and farmer groups in claim verification and awareness campaigns has significantly increased farmer engagement. In contrast, India's insurance model remains largely top-down, with farmers often unaware of coverage terms or claim procedures. Second, while India offers some of the highest premium subsidies globally (up to 98% for small farmers under PMFBY), subsidy alone does not guarantee participation. Uptake remains low among tenant farmers and those in rainfed regions—not due to affordability alone, but because of weak awareness, lack of institutional support, and historical mistrust. By contrast, Nepal and Sri Lanka bundle insurance with other agricultural services, making participation more appealing and functionally relevant (Hasan 2019). Third, the role of technology must be reframed from mere efficiency enhancement to farmer empowerment. While tools like GIS mapping and mobile apps are increasingly used under PMFBY, they often exclude digitally marginalized farmers. Other countries have demonstrated that tech-enabled insurance can work better when accompanied by human mediation, real-time transparency, and local grievance redress mechanisms (Khan et al. 2024). Finally, the reliance on private insurers in India's model has raised concerns about moral hazard, profit-maximization, and regional imbalance. Insurers tend to favor low-risk areas to reduce payouts, thereby skewing protection away from the most vulnerable zones. In contrast, public or community-managed insurance models—as seen in Sri Lanka and parts of Nepal—may offer a more equitable and needs-based alternative. India could benefit from piloting such models, particularly in ecologically fragile and high-risk regions, with actuarial and financial support from the central government. India's crop insurance efforts are unmatched in scale, but they remain limited in their reach and effectiveness. Neighboring countries with far fewer resources have achieved greater inclusiveness and trust through institutional decentralization, community participation, and adaptive program design. As India grapples with worsening climate risks and agrarian distress, it must evolve from a system of reactive financial compensation to one of anticipatory, farmer-centric risk governance. The lessons from South Asia are not merely comparative—they offer a strategic roadmap for transforming crop insurance into a truly resilient and inclusive safety net.

Revisiting land reform within the insurance and credit nexus

The study also brings to the fore the importance of land reform in shaping access to institutional credit and insurance. States with skewed land ownership patterns tend to exhibit lower participation in both credit and insurance markets among smallholders. Redistribution of land and enforcement of tenancy rights—as seen in parts of Nepal and West Bengal—have had measurable impacts on investment behavior and creditworthiness among small and marginal farmers. Without addressing structural land inequalities, reforms in credit and insurance will remain incomplete. Future agrarian policy must place equity at the center, ensuring inclusive access to financial instruments and development programs (Akber et al. 2024).

This study analyzed secondary data from 2016 to 2023 to explore the relationships between agricultural credit, indebtedness, insurance uptake, farm income, and farmer suicides across Indian states. The findings point to a fragmented and unequal agrarian landscape. Marginal and small farmers, who constitute over 85% of agricultural

households in India, continue to be disproportionately excluded from formal credit systems and risk mitigation instruments. States like Andhra Pradesh, Tamil Nadu, and Maharashtra show indebtedness levels above 70%, yet farm incomes remain modest—indicating that high loan penetration alone does not alleviate agrarian distress. Although crop insurance schemes such as PMFBY and RWBCIS have expanded significantly—with over 60 million enrolled farmers in peak seasons—serious challenges persist: delayed settlements, low claim ratios (as low as 30-40% in some states), and low voluntary participation among non-loanee farmers. Our analysis further confirms that states with the highest incidence of farmer suicides also show a persistent mismatch between credit access, insurance efficacy, and income support, reflecting a deeper failure in risk governance. While large and medium farmers access long-term institutional loans for productive investments, smallholders often take short-term loans for survival, reinforcing cycles of debt and vulnerability.

To address these challenges, the following policy implications are proposed under three key thematic areas:

Insurance reform

Improve claim transparency and timeliness: Insurance schemes must incorporate strict timelines for claim settlement and increase accountability for both public and private insurers. Digital monitoring and automatic triggers for payout in weather-based claims can reduce delays (Cariappa et al. 2021).

Enhance voluntary participation: Move beyond credit-linked insurance by actively incentivizing and subsidizing non-loanee farmers, especially smallholders. Awareness campaigns using local languages and community facilitators are essential for improving trust and outreach.

Address regional disparities in coverage: Tailor premium structures and product designs based on agro-climatic zones, with higher subsidies in ecologically fragile or rainfed regions. Risk pooling should account for regional climate variability to ensure fairness.

Introduce farmer-centric grievance mechanisms: Create independent district-level insurance ombudsman offices with farmer representation to resolve disputes swiftly and fairly.

Credit access

Expand access to long-term investment credit: Design targeted schemes for small and marginal farmers that support long-term capital formation (e.g., irrigation, equipment), with flexible repayment windows to accommodate climate risks.

Strengthen SHGs and Farmer Producer Organizations (FPOs): Facilitate group-based lending models that reduce risk for banks while improving bargaining power and creditworthiness for smallholders (NABARD 2018).

Digitize credit delivery and monitoring: Use Aadhaar-linked accounts and mobile platforms to streamline loan disbursal, track usage, and monitor repayment behavior, thereby minimizing leakages and enhancing efficiency.

Link credit to income-enhancing activities: Integrate credit with input subsidies, extension services, and minimum support prices (MSP) to ensure that loans translate into actual income gains, not cyclical debt.

Smallholder protection

Universalize access to risk mitigation tools: Make basic crop insurance and credit guarantee coverage universal for all landholding farmers, with special provisions for tenant farmers and women cultivators often excluded from formal systems.

Promote diversified livelihoods: Support programs that offer allied income sources (e.g., dairy, poultry, horticulture) in addition to crop farming, thereby reducing income volatility and improving resilience.

Mental health and legal aid services: Integrate rural mental health outreach and legal support into agriculture extension programs, particularly in suicide-prone districts (Dandekar and Bhattacharya, 2017).

State-level risk assessment cells: Establish specialized units within State Agriculture Departments to assess local risk patterns (climatic, economic, social) and inform timely interventions at the district level, incentivize insurance participation among smallholders by offering full premium subsidies and simplifying enrollment processes, especially in regions with high debt burdens, decouple crop insurance from credit linkage, allowing non-loanee farmers equal access to protection schemes, particularly after the shift to voluntary participation post-2020, and integrate financial literacy, credit counseling, and risk management education into agricultural extension services to improve trust and informed decision-making among vulnerable farmer groups.

Mitigating agrarian distress in India requires a shift from fragmented interventions to integrated, equity-oriented solutions. Credit, insurance, and income support must be designed not merely as schemes but as components of a broader, farmer-centric risk governance system. Only then can India move toward a more inclusive and sustainable rural economy.

The data confirms that small and marginal farmers face higher levels of indebtedness, they receive a disproportionately low share of institutional crop loans and remain underrepresented in crop insurance enrollment. This suggests that landholding size remains a structural barrier—larger landowners are more likely to access formal credit, which in turn increases their likelihood of being insured, especially under credit-linked schemes like PMFBY. Thus, credit access appears to mediate insurance uptake, reinforcing existing inequalities. Our findings also suggest that indebtedness plays a dual role. On one hand, heavily indebted farmers may seek insurance as a form of risk mitigation (a pull factor). On the other, limited trust in claim settlement, poor outreach, and liquidity constraints may deter them from enrolling, especially after the 2020 policy shift that made insurance optional for loanee farmers. This is evident from the insignificant post-policy change in enrollment ($p=0.099$) and the low claim settlement ratios in some states. Therefore, debt may act as both a signal of vulnerability and a barrier to participation, depending on local institutional conditions. These patterns have important policy implications. First, risk mitigation schemes like PMFBY may not reach the most vulnerable

farmers unless decoupled from formal credit or made fully subsidized for smallholders. Second, credit outreach alone is not sufficient; the design of insurance must address delivery failures, region-specific pricing, and farmer trust. Finally, a more integrated approach linking financial literacy, crop insurance, and credit counseling within agricultural extension services is necessary to reduce agrarian distress meaningfully.

Limitations and future research

This study is constrained by its use of secondary, aggregated state-level data, which may obscure intra-state heterogeneity and farmer-specific dynamics. Additionally, the statistical power of the paired T-test is limited by a small number of observations. Future research should employ disaggregated, farm-level panel data to explore causality with greater precision, address potential endogeneity in regression models, and investigate intersecting factors such as land tenure, gender, crop types, and regional agro-climatic risks. Such research would offer a more granular understanding of how policy instruments can be tailored to enhance the economic resilience of India's most vulnerable farming populations.

We acknowledge that India's agro-economic landscape is highly diverse, with wide inter-state variation in land fragmentation, rainfall risk, credit penetration, and crop insurance implementation. While our analysis is state-level and presents aggregated trends, we do not disaggregate by agro-climatic zone or geographic region due to limitations in the dataset's structure and the absence of zone-specific policy data. Future research should incorporate spatial variation, such as comparing high- and low-rainfall regions or North vs. South India, to understand how ecological and administrative differences shape insurance participation and indebtedness patterns. Such analysis could further clarify whether observed disparities are driven by agro-climatic risk, institutional outreach, or socio-political factors.

Moreover, the model may be subject to omitted variable bias, as we were unable to control for factors such as education, access to extension services, crop type, rainfall variation, and local institutional conditions. These factors may simultaneously influence both indebtedness and insurance participation. Due to data constraints, we also did not conduct robustness or sensitivity checks, such as instrumental variable estimation or multivariate analysis. Therefore, the findings should be interpreted as exploratory, and we strongly recommend future research using more granular, micro-level datasets.

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