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ARTICLE

Rainfall Variability, Risk, and Resilience: A Comparative Study of Insured vs. Non-Insured Farmers in Maharashtra, India

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ABSTRACT

This paper examines the risks involved in Maharashtra's agriculture and investigates the mitigation strategies adopted by insured and non-insured farmers in Latur and Pune districts. By using a multi-stage sampling method, 400 sample households were selected from two districts. These households comprise 268 insured farmers and 134 non-insured farmers. The results reveal that both rainfall variability and reductions in crop prices significantly impact agricultural revenues. However, the specific risk that carries the most significant weight may vary depending on an individual's insurance status. Insured farmers are most vulnerable to the unpredictable nature of rainfall, as insurance typically protects against yield losses but not necessarily against market fluctuations. Conversely, non-insured farmers face a constant threat from declining crop prices, even with a good harvest, as they lack the financial buffer provided by crop insurance. This study suggests that the government should integrate pricing risk with crop insurance to reduce risk in agricultural production. Additionally, the farmers should adopt an integrated approach to pest and disease management. The implementation of a comprehensive crop insurance program is needed to ensure equitable coverage for farmers, facilitating widespread benefits. Additionally, more efforts should focus on mitigation of identified risks such as input costs, market fluctuations, and production uncertainties.

Keywords: Risk in agriculture; Non-insured farmers; Crop insurance; Maharashtra

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1. Introduction

The agricultural sector has been significantly affected by occurrences of unseasonal rain and hailstorms, leading to considerable damage and disrupting agricultural activities[1]. Each of these factors has a connection to climate change, which severely impacted the agricultural production system [2]. The possible effects of climate change on agricultural crop productivity have been extensively recognized in the previous studies and literature [2–6]. These studies demonstrate how climate change has a major detrimental impact on crop yields. By observing the global scenario of agricultural risks, agriculture is characterized by inherent risk and uncertainty, primarily stemming from yield and income instability. Unfavourable weather conditions, rainfall variability and natural disasters significantly affect production and costs, necessitating investments and resource allocations well in advance of knowing actual yields and prices[7]. The adverse effects of climate change on Indian agriculture are exacerbated by the fact that 16% of the country's land area is considered drought-prone, making recurring drought a major challenge in these areas[8]. As a result of this, India has experienced significant agrarian suffering over the past decade[9]. The most significant risk factors identified are undoubtedly rainfall variability, debt and associated factors [10, 11].

Within the context of agricultural systems, risk pertains to the various decisions that farmers make, drawing from their past experiences and associated knowledge of the likelihoods of future agricultural output [12]. Agricultural activity is subject to several sources of risk such as risk of not realizing expected yield, not achieving expected price, not achieving expected quality of output, loss during storage and transportation stages, and various input risks. To overcome these risks, the farmers adopt mitigation strategies include shifting to different crops, diversifying crop types, leaving land fallow after potential drought periods, switching from traditional irrigation to drip and sprinkler methods, adjusting the planting schedule, and cultivating drought-resistant crop varieties[4, 13]. Apart from these strategies, crop insurance is one of the popular instruments adopted by the farmers as it assists farmers in managing risks and stabilizing their income and consumption, enabling them to cope with unfavourable events such as pests, droughts, and harsh weather exacerbated by climate change[14]. However, Mukherjee and Pal identified several barriers contributing to the limited adoption of agricultural insurance schemes, including inadequate awareness among farmers, diminished confidence due to delays in claim payments, and lack of comprehensive coverage tailored to specific agricultural needs[15]. In addition to these reasons, insufficient staffing and inadequate coordination among personnel are significant barriers that hinder the effective delivery of benefits to farmers[16]. Addressing these challenges is crucial for enhancing the accessibility and effectiveness of agricultural insurance initiatives aimed at bolstering farmer resilience and sustainability in the sector [17].

By looking at a narrow outlook on rainfall variability related issues, the state of Maharashtra covers half of the region prone to drought, and the state has a severe drought once every eight to nine years and a deficiency of rainfall once every five to six years[5]. According to estimates provided in the Rastriya Krishi Vikas Yojana (RKVY) report, approximately 80% of the state's agriculture is rain-fed, reliant solely on rainfall for crop cultivation, and considerable variability exists in rainfall patterns across different state regions[18, 19]. According to indices of the monsoon variability index, Vidarbha and Marathwada regions of Maharashtra are more vulnerable[20], and exacerbates the challenges faced by farmers, leading to financial distress, crop failures, and family burdens[21]. Therefore, it is imperative to analyze the risks inherent in agriculture and mitigation strategies employed by farmers to propose viable solutions and policy measures aimed at addressing the sector's vulnerabilities. It is also necessary to examine the mitigation strategies adopted by insured farmers and non-insured farmers as agricultural insurance emerges as a highly effective strategy for managing the inherent risks in farming.

Objective:

To determine the risk associated with Maharashtra's agricultural sector and the attitude of farmers in order to reduce that risk.

2. Data and Methodology

A multi-stage sampling approach was adopted, beginning with the selection of study districts through stratified sampling based on irrigation criteria [22]. Maharashtra State was chosen as the focal area for this study due to the pivotal role of agriculture and related activities in its economy, with approximately half of the state's population dependent on this sector for livelihood. Within Maharashtra's agriculture sector, crops contribute significantly, comprising an average share of 63.7% (Economic Survey of Maharashtra, 2021–2022)[23]. For the purpose of primary data collection, two districts were selected, and while selecting the districts, the basis was availability and extent of irrigation cover. Latur district, representing a drought-prone area with only 9.19% of its land under irrigation—below the state average of 17.82%, and Pune district, characterized by a higher irrigated area at 27.28%, above the state average—were chosen. Latur belongs to Marathwada region, while Pune represents western Maharashtra. Subsequently, two blocks per district were selected—Nilanga and Ausa blocks from Latur district, and Junnar and Indapur blocks from Pune district. For this study purpose, a random sampling method was used while selecting the respondents from both the districts. Finally, 100 farmer households were randomly selected from each block, comprising 67 insured and 33 non-insured farmers, totaling 400 sample households across the two districts. To make analysis more meaningful, the paddy growers were selected as respondents from Pune district and soybean growers from Latur district, where soybean cultivation dominates more than 50% of the study area.

The data collection exercise for this study was conducted in 2022. The study employed primary data collection methods to gather the information. Primary data were collected from growers on socio-demographic profile, risk associated in agriculture, adoption of risk mitigation strategy, etc., through pre-tested interview schedules from the selected farmers. Descriptive statistics were employed for data analysis. To determine how far the farmers' tendency towards risk aversion deviates from the expected risk, we have utilized the standard deviation using following formula.

$$SD = \sqrt{\sum(x-\mu)^2/N} \quad (1)$$

where, Σ means "sum of", x is a value in the data set, μ is the mean of the data set, and N is the number of data points in the population.

The independent-samples (t) test was used to evaluate the difference between the means of two independent or unrelated groups. That is, we evaluated whether the means for two independent groups are significantly different from each other. The relationship between crop insurance and stability of gross farm income was tested using independent-samples (t) test. This methodological framework ensures robust data collection and analysis, facilitating a comprehensive examination of agricultural risk management strategies and their implications for policy and practice in Maharashtra's agricultural landscape.

To evaluate the relative variability in the prices of different major crops, this study computed the Coefficient of Variation (CV). The CV, expressed as a percentage, provides a measure of the extent of variability in relation to the mean price. A higher CV indicates greater price volatility; whereas a lower CV reflects more stable prices.

3. Results and Discussions

3.1. Land Ownership of Sample Respondents

Table 1 and **Figure 1** present the distribution of average landholdings according to land size categories: marginal (less than 2.5 acres), small (2.5 to 5 acres), medium (5.1 to 7.5 acres), and large (greater than 7.5 acres). On average, the landholding size among respondent farmers was approximately 5.76 acres for insured farmers (IF) compared to 4.31 acres for non-insured farmers (NIF). A district-wise analysis reveals that in Latur district, insured farmers possessed an average of 6.11 acres, while non-insured farmers held 3.63 acres. In Pune district, the average landholding was 5.4 acres for insured farmers and 5 acres for non-insured farmers.

Table 1. Operational land holding of sample households.

Holding	Latur			Pune			Total		
	NIF	IF	Total	NIF	IF	Total	NIF	IF	Total
UP TO 2.5	48	29	36	15	6	9	32	18	22
2.5 TO 5	36	37	37	48	30	36	42	34	37
5 TO 7.5	8	8	8	21	57	46	14	33	27
< 7.5	8	25	20	15	7	10	11	16	15
Total	100	100	100	100	100	100	100	100	100

Source: Field survey.

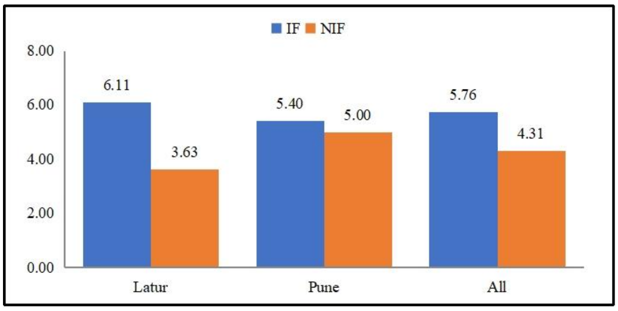

Figure 1. Average land holding of sample households.

The comparative analysis of average landholdings by irrigation availability presented in **Table 2**, which reveals that insured farmers manage significantly more land than their non-insured counterparts. For example, insured farmers in Pune possessed an average of 10.82 hectares of irrigated land, in contrast to only 1.59 hectares for insured farmers in Latur. Overall, the total landholding for insured farmers in Pune averaged 10.85 hectares, markedly higher than the 5.29 hectares observed in Latur. These findings suggest that insurance status is correlated with larger landholdings, while regional disparities indicate that Pune's higher land averages may reflect more favorable economic conditions or greater access to irrigation facilities compared to Latur district.

3.2. Source of Irrigation

The overall percentage of net irrigated area to total cropped area in Maharashtra was 17 percent, indicating that a significant portion of cultivation relies on rainfall patterns. Irrigation plays a crucial role in determining land use patterns, often shifting cultivation towards cash and horticultural crops. The frequent occurrence of crop failures in many parts of Maharashtra is largely attributed to inadequate irrigation facilities. The primary sources of irrigation in the state include tube wells, canals, wells, tanks, and rivers. Among the respondents, approximately 70 percent reported having access to irrigated land, while around 30 percent were dependent on rain-fed agriculture.

The data in the **Table 3** indicates that the principal source of irrigation for respondents was wells, accounting for 49.5 percent of the total, followed by multiple sources (such as wells, tube wells, rivers, and tanks) at 11.5 percent, and tube wells at 9.8 percent. Additionally, it is evident that more than half of the respondents relied on rain-fed agriculture, depending primarily on rainfall for cultivation. In Latur, tube wells were the most dominant source of irrigation (18.5 percent), followed by wells (13.5 percent), and 9.7 percent of farmers utilized more than two sources of irrigation. In contrast, in Pune district, approximately 86 percent of farmers used wells for irrigation; while around 12 percent had access to more than one source of irrigation. These findings suggest that Latur, being more drought-prone, has limited irrigation facilities, compelling cultivators to rely heavily on rainfall, whereas Pune has a higher proportion of irrigated land.

3.3. Risk Factors Affecting Agriculture Production

During the survey, respondents were asked regarding perceived agricultural risks, which were quantified as percentages and summarized in **Table 4**. In Latur, both Insured Farmer (IF) and Non-insured Farmer (NIF) respondents opined that decline in crop prices as the most significant risk factor, with 92.9% acknowledging its impact. This was followed by concerns over drought conditions stemming not only from insufficient rainfall variability but also from overall rainfall variability, noted

Table 2. Average land holdings (in hectares) by irrigation availability.

Item	Average of Irrigated	Average of Non-Irrigated	Average of Total Land
Insured farmer	2.17	3.94	6.11
Non-insured farmer	0.40	3.23	3.63
Latur	**1.59**	**3.70**	**5.29**
Insured farmer	9.19	0.03	9.22
Non-insured farmer	14.13	0.05	14.18
Pune	**10.82**	**0.04**	**10.85**

Table 3. Source of irrigation of sample households.

Source	Latur			Pune			Overall		
	IF	NIF	Total	IF	NIF	Total	IF	NIF	Total
Tube-well	25.4	4.5	18.5	0.7	1.5	1.0	13.1	3.0	9.8
Well	16.4	7.6	13.5	88.1	80.3	85.5	52.2	43.9	49.5
Tank	0.7	0.0	0.5	0.0	0.0	0.0	0.4	0.0	0.3
River	0.0	1.5	0.5	0.0	0.0	0.0	0.0	0.8	0.3
Depend on Rainfall	46.3	77.3	56.5	1.5	0.0	1.0	23.9	38.6	28.8
More than one source	11.2	9.1	10.5	9.7	18.2	12.5	10.4	13.6	11.5
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Source: Field survey.

by 62.1% of respondents. Additionally, respondents cited crop diseases, typically spread through the entire plant (40.9%), investment failures (37.9%), and pest attacks, generally chew and suck on plant leaves (36.4%) as substantial risks affecting crop production.

In the Pune district, variability in rainfall was perceived as the foremost risk by both IF and NIF respondents, with 99% highlighting its importance. Following closely were concerns related to pest and disease outbreaks and the impact of declining crop prices. Notably, all households surveyed in Latur reported experiencing yield losses due to drought conditions, exacerbated by variable rainfall patterns. The study finds that variability in rainfall and declines in crop prices emerged as the primary contributors to agricultural losses within the study area.

According to government data, Latur receives 801.04 mm (https://zplatur.gov.in/htmldocs/leftframe/aboutLatur.htm#: :text=Air%20remains%20humid%20in%20rainy,south%2Dwest%20monsoon%20gives%20rain) of rainfall on average, compared to Pune's 650–700 mm (https://pune.gov.in/about-pune/district-at-a-glance/#: :text=Summer%20%3A%2022%C2%B0C%20TO,Rainfall%20%3A%20650%20To%20700%20-mm.&text=It%20lies%20between%2018%C2%B0,73-%C2%B0%2051%E2%80%B3%20East%20longitude). It means, Latur receives more rainfall than Pune. The Central Ground Water Board Report on Dynamic Groundwater Resources of Maharashtra (2022), states that Sahyadris act as a barrier to the advancing southwest monsoon and form a rain shadow zone on the eastern side where the rainfall is generally between 400–700 mm. Thus, the central part of the State almost always reels under scarcity (Pune falls under western-central part of Maharashtra). The regions of Marathwada and Vidharbha receive up to 1250 mm rainfall and falls within assured rainfall zone (Latur comes under the Marathwada region). This could be a probable reason for farmers' opinions that varied rainfall is the biggest risk to agriculture in the Pune district; while falling prices are the biggest risk to agriculture in the Latur district.

In general, insured farmers identified variability in rainfall as their primary risk factor; whereas non-insured farmers cited a decline in crop prices as their principal concern in agriculture. Consequently, decline in crop prices is the predominant risk factor overall. Both groups of farmers also acknowledged pesticide use and crop diseases as significant risks, alongside the persistent risk posed by declining crop prices.

Unseasonal rainfall in Pune district has been ob-

Table 4. Risk factor affecting agriculture production (in per cent).

Risk Factors	Latur		Pune		Overall Average					
	IF	NIF	IF	NIF	IF	Rank	NIF	Rank	Overall Aaver-age	Rank
Variability in rainfall	61.2	62.1	98.5	100	79.9	I	81.1	II	80.5	II
Pest disease	41	36.4	98.5	98.5	69.8	III	67.5	IV	68.6	IV
Crop disease	40.3	40.9	97.8	98.5	69.1	IV	69.7	III	69.4	III
Decline in crop prices	90.3	95.5	54.5	98.5	72.4	II	97.0	I	84.7	I
Failure technology	9.7	3	0	0	4.9	VI	1.5	VI	3.2	VI
Failure investment	44.8	37.9	0.7	0	22.8	V	19.0	V	20.9	V

Note: IF—Insured Farmer and NIF—Non-insured Farmer. Source: Field survey.

served to significantly impair crop yield and quality. The excessive rainfall has led to crop inundation and premature germination, causing substantial damage, with farmers expecting a reduction in harvest by more than 50%. These findings highlight the vulnerability of agricultural systems to unexpected weather events and underscore the need for adaptive strategies to mitigate such risks. In Latur district, price volatility is a major concern, particularly for soybean, the main crop. Farmers have had to store their produce for the past two years due to unfavorable market prices. Similarly, unseasonal rains pose a serious threat in Pune, where cereals, fruits, and vegetables are the primary crops. These weather anomalies can severely damage crops during both the growing and harvesting stages.

3.4. Impact of Rainfall Variability on Soybean Productivity in Latur

To assess the impact of rainfall on crops, we selected soybean from Latur district, given its status as the most important agricultural crop in the region, and paddy from Pune district. These crops were chosen due to their significance in the respective districts and their susceptibility to variations in rainfall.

The analysis of rainfall and soybean productivity data from 2017 to 2022 mentioned in the **Table 5**, demonstrates a strong correlation between actual rainfall and crop yield. Although the average actual rainfall closely aligns with the normative value of 639 mm, there are significant fluctuations, with actual rainfall ranging from 66% to 127% of this norm. Soybean productivity responds clearly to these variations; higher rainfall percentages generally correlate with increased yields, as evidenced by peak yields of 1750 kg·ha^{-1} in 2020 and 1228 kg·ha^{-1} in 2021. Conversely, reduced rainfall in years such as 2018 and 2019 resulted in lower yields. The data indicates that while yield variability is less pronounced than rainfall variability, rainfall remains a critical factor, though other factors also contribute to soybean productivity.

3.5. Impact of Rainfall Variability on Paddy in Pune

The analysis of the relationship between rainfall and paddy productivity in Pune district from 2017 to 2022 presented in **Table 6(a)**, which indicates that deviations in actual rainfall from the norm significantly impact crop yields. Despite substantial variations in rainfall, ranging from 102% to 180% of the normative value, paddy productivity varied considerably, with yields between 1809 kg·ha^{-1} and 2789 kg·ha^{-1}. For example, in 2021, with actual rainfall at 102% of the norm, productivity reached a peak of 2095 kg·ha^{-1}. In contrast, in 2017 and 2019, despite higher rainfall percentages of 180% and 176%, productivity was lower at 2157 kg·ha^{-1} and 1833 kg·ha^{-1}, respectively. Statistical measures reveal a mean rainfall of 862 mm and a mean paddy productivity of 2178 kg·ha^{-1}, with standard deviations of 210.61 mm for rainfall and 368.73 kg·ha^{-1} for productiv- ity. The coefficient of variation is 24.43% for rainfall and 16.93% for productivity, indicating notable variability in both parameters.

The analysis of rainfall data for Ausa and Nilanga Talukas from 2017 to 2022 presented in **Table 6(b)**, reveals distinct differences in rainfall patterns and variability. Ausa demonstrates considerable variability, with a total Coefficient of Variation (CV) of 30.8%, indicating significant fluctuations in rainfall across different

Table 5. Rainfall pattern and productivity of soyabean crop.

Year	Normal Rainfall (mm)	Actual Rainfall	% To Normal	Productivity of Soyabeen (in kg·ha^{-1})
2017	639	637	100	1184
2018	639	423	66	1439
2019	639	480	75	1103
2020	639	790	124	1750
2021	639	814	127	1228
2022	639	682	107	1098
CV		**25.00**		**19.46**

months. Notably, the CVs for June, July, August, and September are relatively high, reflecting considerable deviation from normal rainfall values. In contrast, Nilanga exhibits a lower overall CV of 19.8%, suggesting more stable rainfall patterns. Although the CVs for Nilanga are highest in July and August, the overall rainfall variability is less compared to Ausa. Both Talukas experienced higher total rainfall in 2020 and 2021, though the reliability and predictability of this rainfall varied. These findings imply that while Nilanga benefits from more stable rainfall, Ausa's more erratic rainfall could pose challenges for agricultural planning and water resource management in these regions.

The analysis of rainfall data for Junnar and Indapur from 2017 to 2022 presented in **Table 6(c)**, reveals notable differences in rainfall patterns and variability. Junnar demonstrates more stable rainfall patterns, with total rainfall ranging between 607.6 mm and 1067.6 mm and a lower overall Coefficient of Variation (CV) of 24.4%, indicating moderate variability. In contrast, Indapur exhibits greater variability, with rainfall ranging from 191 mm to 749.1 mm and a higher total CV of 42.9%. For Indapur, the CVs are highest in August and July, highlighting greater unpredictability, whereas September is the most variable month for Junnar. These findings suggest that Indapur experiences more erratic rainfall, which could have more pronounced effects on water management and agricultural planning compared to Junnar.

3.6. Potential Risk Factors Affecting Farm Income

Farm businesses face various risks that affect farm income[24]. **Table 7** presents the various risk factors affecting farm income.

During the data collelction, the farmers were asked to rank the most significant risk factors affecting their cultivation practices in terms of their impact on farm income. The responses revealed that production risk was identified as the foremost concern by 97.1% of both Insured Farmer (IF) and Non-insured Farmer (NIF) respondents. Market price risk followed closely, with 95.3% of farmers highlighting its importance, and the availability of inputs was considered significant by 72.6% of respondents. Quality of inputs, variability in input prices, and changes in government policies were each mentioned by 32% to 37% of respondents, indicating their moderate concern compared to production and market price risks. Given these findings, it is evident that the Latur district faces considerable vulnerability to risk associated crop losses. Furthermore, surveyed farmers generally perceived technology risk as less impactful on farm income compared to other identified risks.

3.7. Attitude among Farmers towards Risk

Agricultural producers navigate decision-making within a complex and uncertain environment characterized by risks stemming from production factors such as weather variability, disease outbreaks, and pest infestations. They also contend with uncertainties in market dynamics and prices affecting both input and output, alongside financial uncertainties influenced by factors

Table 6. (**a**) Rainfall pattern and productivity of paddy crop. (**b**) Rainfall variability in a selected block of Latur. (**c**) Rainfall variability in a selected block of Pune.

(a)

Year	Normal Rainfall	Actual Rainfall	% To Normal	Productivity of Paddy (in kg·ha^{-1})
2017	594.2	1067.6	180	2157
2018	594.2	773.1	130	2386
2019	594.2	1048.2	176	1833
2020	594.2	649.9	109	1809
2021	594.2	607.6	102	2095
2022	594.2	1027	173	2789
CV		**24.43**		**16.93**

(b)

Year	Taluka	June		July		Aug		Sept		Total	
		Noramal	Actual	Noramal	Actual	Noramal	Actual	Noramal	Actual	Noramal	Actual
2017	Ausa	136.4	193.5	147	48.8	154.5	249.6	174.8	130	612.7	621.9
	Nilanga	138.4	184.7	161	58.6	173.6	263.8	191.9	144.2	664.9	651.3
2018	Ausa	136.4	178.8	147	78.2	154.5	97.2	174.8	8.2	612.7	362.4
	Nilanga	138.4	257.7	161	92	173.6	118.2	191.9	16.2	664.9	484.1
2019	Ausa	136.4	56.1	147	84.4	154.5	141.6	174.8	159.6	612.7	441.7
	Nilanga	138.4	82.7	161	88	173.6	188.1	191.9	159.4	664.9	518.2
2020	Ausa	136.4	161.4	147	152.5	154.5	112.9	174.8	364.6	612.7	791.4
	Nilanga	138.4	180.1	161	187.9	173.6	102.1	191.9	317.7	664.9	787.8
2021	Ausa	136.4	174.5	147	221.1	154.5	179.3	174.8	275.4	612.7	850.3
	Nilanga	138.4	136.4	161	238.7	173.6	148.5	191.9	254.2	664.9	777.8
2022	Ausa	136.4	66.3	147	283.6	154.5	77.5	174.8	219.6	612.7	647
	Nilanga	138.4	85.7	161	303	173.6	90.03	191.9	237.3	664.9	716.03
CV	Ausa		43.9		63.6		44.2		64.0		30.8
	Nilanga		43.3		60.4		43.0		56.2		19.8

Source: maharain.maharashtra.gov.in.

(c)

Year	Taluka	June		July		Au		Sep		Total	
		Noramal	Actual	Noramal	Actual	Noramal	Actual	Noramal	Actual	Noramal	Actual
2017	Junnar	115.4	188.1	219	494.2	146.4	252.6	113.4	132.7	594.2	1067.6
	Indapur	102.1	212.7	81.2	22.1	84.3	116.9	159.4	197.8	427	549.5
2018	Junnar	115.4	114.6	219	366.2	146.4	253.3	113.4	39	594.2	773.1
	Indapur	102.1	105.7	81.2	33.7	84.3	25.8	159.4	25.8	427	191
2019	Junnar	115.4	118.3	219	444.4	146.4	282.2	113.4	203.3	594.2	1048.2
	Indapur	102.1	59.8	81.2	100.6	84.4	22.3	159.4	153.4	427.1	336.1
2020	Junnar	115.4	167.1	219	128.2	146.4	208.8	113.4	145.8	594.2	649.9
	Indapur	102.1	208.4	81.2	152.9	83.3	86.1	159.4	301.7	426	749.1
2021	Junnar	115.4	127.6	219	189.1	146.6	65.5	113.4	225.4	594.4	607.6
	Indapur	102.1	107.3	81.2	134.5	84.3	44.3	159.4	101.1	427.7	387.2
2022	Junnar	115.4	125.5	219	380.6	146.4	168.5	113.4	352.4	594.2	1027
	Indapur	102.1	98.1	81.2	137.1	84.3	145.2	159.4	208.5	427	588.9
CV	Junnar		21.5		43.3		38.6		57.6		24.4
	Indapur		47.9		58.0		69.3		57.8		42.9

Source: maharain.maharashtra.gov.in.

like fluctuating interest rates[25].

Table 8 indicates that the average scores for both Insured Farmers (IF) and Non-insured Farmers (NIF) assessing risk statements are relatively low, suggesting a tendency towards risk aversion among these farmers[26]. When inquired about their willingness to experiment with new farming techniques, a small percentage (4.5%) of farmers expressed readiness to take technological risks, similar to their willingness to take risks in terms of production and income. Regarding credit uptake and timely repayment, farmers generally reported moderate levels of risk-taking behaviour across these factors. Insured farmers prioritized taking risks for higher income, indicating a willingness to venture into riskier agricultural endeavors for potentially greater financial gains. In contrast, non-insured farmers expressed a readiness to undertake risks aimed at achieving higher returns, specifically within agriculture.

3.8. Risk Management Strategies

Risk management strategies in agriculture encompass a range of measures, including crop insurance, land sale or mortgage, bank loans, and government relief programs[27]. Respondents were surveyed to ascertain their utilization of these strategies in response to crop failures or other losses. The findings detailed in **Table 9** highlight the predominant approaches adopted by farmers for risk mitigation. Insured Farmers (IF) consistently

Table 7. Rainfall variability in a selected block of Latur.

Risk Factors	Latur		Pune		Overall Average					
	IF	NIF	IF	NIF	IF	Rank	NIF	Rank	Overall Total Average	Rank
Production Risk	98.5	98.5	95.2	96.2	96.85	I	97.4	I	97.1	I
Market Price Risk	98.5	97	92.3	93.5	95.4	II	95.3	II	95.3	II
Availability of Inputs	88.8	92.4	48.5	60.5	68.65	III	76.5	III	72.6	III
Quality of Inputs	16.4	21.2	49.3	52.3	32.85	VI	36.8	V	34.8	VI
Variability Input Prices	14.9	18.2	51.5	60.1	33.2	V	39.2	IV	36.2	IV
Changes in Govt. Policies	23.1	10.6	50.7	60.5	36.9	IV	35.6	VI	36.2	V
Technology Risk	4.5	1.5	0.7	1.5	2.6	VII	1.5	VII	2.1	VII

Source: Field survey.

Table 8. Attitude among surveyed farmers towards risk.

Risk Factors	Latur (in per cent)		Pune (in per cent)		Overall					
					IF		NIF		Overall	
	IF	NIF	IF	NIF	Mean	SD.	Mean	SD.	Mean	SD.
Do you like experimenting with new farming techniques?	73.9	66.7	98.5	100	4.19	1.12	4.36	1.23	4.25	1.16
Do you take risks for higher returns (production)?	82.1	93.9	100	100	4.40	0.75	4.70	0.55	4.50	0.70
Do you take risks for higher income (money)?	84.3	83.3	99.3	100	4.44	0.67	4.63	0.68	4.51	0.68
Do you take more credit than others for managing production risks?	21.6	19.7	96.3	1.5	3.54	1.21	2.83	0.80	3.31	1.14
Timely repayment of loans	6	4.5	97.8	100	3.15	1.56	2.96	1.21	3.09	1.46

Source: Field survey.

prioritized crop insurance as their primary strategy. A significant 62.6% of respondents across both insured and non-insured categories indicated reliance on loans obtained from cooperative banks. In the Latur district, a majority of farmers, both IF and NIF, relied on mortgage of land or other assets, with an around nine per cent interest rate opting for loans from informal money lenders. The cooperative banks/credit societies in the Pune district were identified as the preferred source for crop loans, underscoring their pivotal role in implementing the National Agricultural Insurance Scheme (NAIS). The involvement of both commercial and cooperative banks underscores their crucial role in supporting agricultural risk management efforts.

3.9. Adjustment Mechanism in Case of Rain Failure

An attempt was made to identify the strategies adopted by farmers in response to delays in monsoon rains. The data on adjustment mechanism adopted by farmers in case of rain failure presented in **Table 10**. When asked about their coping mechanisms in the event of rain failure, a majority of insured farmers indicated a preference for waiting for rain, followed by 82.1 per cent, who reported seeking non-farm employment opportunities. A small number of respondents mentioned migrating to urban areas as a coping strategy. In the Pune district, characterized by irrigated typologies and a focus on horticultural crops, farmers whose plots were already sown employed various strategies. Approximately 30.9 per cent of respondents opted to reduce inputs such as fertilizers and pesticides as a means of adaptation to the circumstances.

3.10. Risk Adaptation Actions before Incidence of Crop Loss

The influence of risk aversion levels on farmers' selection of risk-coping strategies is a critical consideration [28]. **Table 11** presents an analysis of pre-emptive risk adaptation measures adopted by farmers before experiencing crop losses. Crop insurance emerges as a prominent strategy for mitigating risk, effectively reducing potential financial losses[29, 30]. Non-farm investments and seeking non-farm employment are also recognized strategies aimed at alleviating financial vulnerabilities during challenging economic periods in agricul-

Table 9. Risk management strategies by surveyed farmers (in per cent).

Risk Management Strategies	Latur		Pune		Overall Average	
	IF	NIF	IF	NIF	IF	NIF
Crop insurance	100	0	100	0	100	0.0
Sale/mortgage of land	44.8	50	0.7	0	22.8	25.0
Bank loan from a commercial bank	30.6	16.7	38.1	1.5	34.4	9.1
Loan from cooperative society	32.8	19.7	97.8	100	65.3	59.9
Borrowing from friends and relatives	8.2	15.2	3.7	1.5	6.0	8.4
Borrowing from money lender	6.7	13.6	0	0	3.4	6.8
Government relief	2.2	3	0	0	1.1	1.5

Source: Field survey.

Table 10. Adjustment mechanism in case of rain failure (in per cent).

Adjustment Mechanism	Latur		Pune		Overall Average		
	IF	NIF	IF	NIF	IF	NIF	Overall
Wait for rain before sowing	97	97	37.3	0	67.2	97.0	82.1
No sowing	23.9	0	45.5	0	34.7	0.0	17.4
Show less	6.7	1.5	51.5	0	29.1	1.5	15.3
Sow substitute crops	18.7	1.5	48.5	1.5	33.6	1.5	17.6
Seek non-farm work	79.9	98.5	51.5	0	65.7	98.5	82.1
Migrate to an urban area	3	1.5	0	0	1.5	1.5	1.5
Invest in allied activity	0.7	1.5	46.3	0	23.5	1.5	12.5
Less use of input	34.3	30.3	57.5	1.5	45.9	15.9	30.9

Source: Field survey.

ture. Furthermore, diversification of crops and income sources is highlighted as a method to mitigate the impact of price fluctuations while maintaining savings from previous periods, which serves as a buffer during periods of poor agricultural production [31].

The data from **Table 11** indicate that crop insurance is widely favored among insured farmers, with all reporting its use as a risk mitigation strategy. This is followed by significant adoption rates of diversification of income sources (80.7 per cent), crop diversification and inter-cropping (79.9 per cent), non-farm employment (21.1 per cent), and non-farm investments (14.4 per cent). These strategies underscore the proactive measures farmers employ to manage agricultural risks and ensure economic resilience. **Table 11** indicates that crop insurance is a prominent strategy of risk mitigation, and this conclusion is consistent with findings from previous studies.

The result indicates that maintaining higher savings and adopting advanced cropping techniques are less frequently utilized strategies to mitigate risk aversion. In the Latur district, non-farm employment is the predominant strategy employed, with 78.8% of respondents opting for this approach. In contrast, in the Pune district, diversification of investments and crops is favored as the primary risk management tool.

3.11. Volatility in Prices of Major Crops in Maharashtra

The Coefficient of Variation (CV) data for major crops in Maharashtra from 2017–2018 to 2021–2022 presented in **Table 12**, indicates varying levels of price volatility. Maize displayed moderate volatility, peaking in 2018–2019 and 2019–2020, but showed signs of stabilization in the subsequent years. Gram exhibited significant variability, with a sharp decline in 2018–2019 followed by fluctuating stability. Tur experienced moderate volatility, with a notable increase in 2018–2019, which later decreased. Soybean displayed the highest volatility, with a dramatic spike in 2020–2021 indicative of severe price instability, though it moderated in 2021–2022. Overall, soybean experienced the most pronounced volatility, whereas maize and tur demonstrated relatively stable patterns with moderate fluctuations.

3.11.1. Comparison with Average Annual Price and Minimum Support Price

Table 13 provides agricultural data for four crops (maize, tur, soybean, and gram) across five years (2017–2018 to 2021–2022) in specific areas (Nandgoan, Akola,

Table 11. Risk adaptation actions before incidence of crop loss (in per cent).

Risk Adaptation Actions	Latur		Pune		Overall Average		
	IF	NIF	IF	NIF	IF	NIF	Overall
Crop insurance	99.3	0.0	100.0	0.0	99.7	0.0	99.9
Non-farm investments	46.3	40.9	3.7	8.4	25.0	24.7	14.4
Crop diversification	39.6	31.8	93.3	63.6	66.5	47.7	79.9
Diversification of income source	38.1	45.5	94.8	88.0	66.5	66.8	80.7
Non-farm employment	75.4	78.8	3.0	12.0	39.2	45.4	21.1
Maintaining higher saving	17.2	12.1	2.2	16.0	9.7	14.1	6.0
Adoption of advanced techniques	7.5	6.1	1.5	9.0	4.5	7.6	3.0

Source: Field survey.

Table 12. Price volatility of major crops in Maharashtra.

Crop	Coefficient of Variation (CV)				
	2017–2018	2018–2019	2019–2020	2020–2021	2021–2022
Maize	9.03	16.72	16.57	15.62	15.62
Gram	12.47	3.82	8.70	8.15	11.07
Tur	6.7	13.7	7.6	7.1	9.3
Soybean	11.1	5.1	5.0	32.4	9.9
Soybean	11.1	5.1	5.0	32.4	9.9

and Latur). The table compares the average annual market prices of these crops to their respective Minimum Support Prices (MSP) set by the government. The data reveals persistent disparities between MSP and actual market prices, with notable volatility across different crops and years. This underscores the ongoing challenges faced by farmers in achieving the MSP, highlighting the need for improved price stability and support mechanisms.

The data reveals notable fluctuations in the average annual prices of crops relative to their Minimum Support Prices (MSP) from 2017–2018 to 2021–2022. For maize, prices often fall below MSP, with significant shortfalls observed in 2017–2018 and 2019–2020, although prices exceed MSP in 2018–2019 and 2021–2022. Tur consistently shows prices below MSP, except in 2020–2021 when prices exceed MSP. Soybean frequently shows positive price differences, particularly in 2020–2021 and 2021–2022, indicating higher market prices compared to MSP. Conversely, gram consistently falls short of MSP across all years, highlighting a persistent shortfall. Overall, the data underscores significant volatility in agricultural markets and the ongoing disparities between MSP and actual market prices, reflecting the challenges farmers face in achieving MSP.

3.12. Crop Insurance and Farm Income Stability

The result of Independent Sample‘t’ Test is given in the **Table 14 (a)** and **14 (b)** below.

For testing relationship, Levene’s Test for Equality of Variances has been to be suitable, and it has revealed that the F Table value is less 1 for the degree of freedom of 398 which is significantly less than the calculated F value of 11.685. Since $p < .001$ is less than our chosen significance level α = 0.05; hence, it may be concluded that there is statistically significant relationship between crop insurance and stability of gross farm income. There was a significant difference in mean gross farm income between insured and non-insured farmers ($t_{278.350}$= 2.339, $p < .001$). The average gross farm income of insured farmers was Rs. 90301.26, more than that of non-insured farmers.

3.13. Reasons for Non-Adoption of Crop Insurance

The data on reasons for non-adoption of crop insurance presented in **Table 15.** Less awareness or no information about the crop insurance’ is most prominent reason reported by the farmers for non-adoption of crop insurance (83.5 per cent), followed by around 59 per cent reported that there is the delay in claim settlement, the

Table 13. Comparison with average annual price and minimum support price (in Rs per Quintal).

Year	Maize-Lasalgaon			Tur-Akola			Soybean-Latur			Gram-Latur		
	Average Annual Price	MSP	Difference over Actual Prices vs. MSP	Average Annual Price	MSP	Difference over Actual Prices vs. MSP	Average Annual Price	MSP	Difference over Actual Prices vs. MSP	Difference over Actual Prices vs. MSP	MSP	Difference over Actual Prices vs. MSP
2017–2018	1209	1425	−216	3845	5420	−1575	3350	3050	300	3732	4400	−668
2018–2019	1921	1700	221	5009	5675	−666	3594	3999	−405	4256	4620	−364
2019–2020	1404	1760	−356	5301	5800	−499	3782	3710	72	4075	4875	−800
2020–2021	1478	1850	−372	6224	6000	224	6126	3880	2246	4776	5100	−324
2021–2022	1952	1870	82	6239	6300	−61	6377	3950	2427	4790	5500	−710

Source: agmarknet.gov.in and desagri.gov.in.

Table 14. (**a**) Relationship between crop insurance and gross farm income. (**b**) Relationship between crop insurance and stability of gross farm income.

(a)

Group Statistics					
Type of Household		**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**
Gross income	IF	268	354318.00	371417.92	22687.96
	NIF	132	264016.74	345472.84	30069.55

(b)

Independent Samples Test						
Gross Income	**Levene's Test for Equality of Variances**		**T-Test for Equality of Means**			
	F	**Sig.**	**t**	**df**	**Sig. (2-Tailed)**	**Mean Difference**
Equal variances assumed	11.685	.001	2.339	398	.01983	90301.26
Equal variances not assumed			2.397	278.350	.01718	90301.26

very low payout , and failure to pay the premium. In particular case of Latur district, the most important reason for not insuring the crops wasdelay in claim settlement (89 per cent), followed by "no information" (76 per cent), "not able to pay premium"(71 per cent), "payout was very low" (65 per cent) , "no trust" (38 per cent), "crops didn't cover" (26 per cent) and "no need of crop insurance" (6 per cent). In Pune, farmers reported that "no information" (91 per cent), "payout is very low" (53 per cent), "not able to pay the premium" (45 per cent), no trust and delay in claim settlement (30 per cent respectively).

4. Conclusions and Policy Implications

Agricultural activity is subject to several sources of risk. Therefore, it was imperative to analyze the risks inherent in agriculture and mitigation strategies employed by farmers to propose viable solutions and policy measures aimed at addressing the sector's vulnerabilities. In conclusion, agricultural revenues are significantly influenced by both rainfall variability and fluctuations in crop prices. This finding is supported by earlier studies done by Chuang [32] and Zachariaah et al. [33]. The predominant risk faced by farmers varies based on their insurance coverage. Insured farmers are particularly vulnerable to the unpredictable nature of rainfall, as insurance typically safeguards against yield losses rather than market price volatility. Conversely, non-insured farmers face a constant threat from declining crop prices, even with a good harvest, as they lack the financial support provided by crop insurance. In Latur, both Insured Farmer (IF) and Non-insured Farmer (NIF) respondents felt that the decline in crop prices as the most significant risk factor; while in Pune, the variability in rain-

Table 15. Reasons for Non-adoption of Crop Insurance.

Reasons	Latur	Pune	Overall
Not able to pay the premium	71.0	45.0	58.0
No need	6.0	0.0	3.0
Payout is very low	65.0	53.0	59.0
Did not get in past	2.0	0.0	1.0
Our crops don't cover	26.0	0.0	13.0
Delay in claim settlement	89.0	30.0	59.5
No information	76.0	91.0	83.5
No Trust	38.0	30.0	34.0

Source: Field survey.

fall was perceived as the foremost risk by both IF and NIF respondents. In general, insured farmers identified the variability in rainfall as their primary risk factor; whereas non-insured farmers cited a decline in crop prices as their principal concern in agriculture. Therefore, crop insurance functions as a safety net for insured farmers, enabling them to consider higher-yield strategies with greater confidence, shielded from the vagaries of weather. In contrast, non-insured farmers prioritize security and adopt more conservative approaches to mitigate the risk of price declines, lacking this financial cushion. This underscores the pivotal role of agricultural insurance in promoting a risk-tolerant farming environment that can potentially enhance productivity. Non-farm investments and seeking non-farm employment are also recognized strategies aimed at alleviating financial vulnerabilities during challenging economic periods in agriculture. Less awareness or no information about the crop insurance is the most prominent reason reported by the farmers for non-adoption of crop insurance

The findings emphasize that price risk is the most influential factor impacting farmers' income. To mitigate risks in agricultural production, it is recommended that the government integrate price risk management with crop insurance schemes. Furthermore, adopting an integrated approach to pest and disease management is advised to enhance agricultural productivity and reduce production risks. Addressing structural constraints is crucial for achieving widespread coverage of crop insurance across India, ensuring equitable access for all farmers. Efforts should focus on implementing comprehensive crop insurance programs that effectively cover all farmers alongside measures to mitigate identified risks such as hike in input costs and market/price volatility. These initiatives are essential for enhancing the resilience of agricultural livelihoods and sustaining economic stability in the farming sector.

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The data used for the study are available upon request from the author.

Conflict of Interest

All authors disclosed no conflict of interest.

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