

# Livelihood vulnerability and resilience of rainfed rice farmers to climate change in Java, Indonesia

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**Abstract.** Rozaki Z, Saputri RD, Kamarudin MF, Rahmawati N. 2026. Livelihood vulnerability and resilience of rainfed rice farmers to climate change in Java, Indonesia. *Asian J Agric* 10 (1): g100108. <https://doi.org/10.13057/asianjagric/g100108>. Climate change, characterized by altered rainfall patterns, rising temperatures, prolonged droughts, and increasing pest infestations, poses significant challenges for rain-fed rice farmers who heavily depend on rainfall. This study assesses and compares the resilience of rainfed rice farmers in Central Java (Klaten, Karanganyar, Boyolali, and Wonogiri) and Yogyakarta (Gunungkidul and Bantul), Indonesia, using the Livelihood Vulnerability Index (LVI). The research involved 300 respondents from six districts, selected through purposive sampling, with data collected via structured household interviews covering social, economic, physical, environmental, and institutional indicators. The LVI was constructed by normalizing indicators and aggregating them into exposure, sensitivity, and adaptive capacity dimensions using a weighted average approach. The results reveal moderate adaptive capacity in both provinces ( $A=0.36$  in Central Java and  $0.39$  in Yogyakarta), with overall vulnerability classified as medium ( $LVI=0.40$  and  $0.46$ , respectively). However, the primary drivers of vulnerability vary across regions. In Central Java, education level ( $p=0.001$ ) and household size ( $p=0.008$ ) significantly influence vulnerability, indicating that limited human capital and higher dependency ratios increase sensitivity to climate shocks. In contrast, farming experience is the dominant factor in Yogyakarta ( $p=0.010$ ), indicating that long-term reliance on traditional practices may limit adaptive responses to changing climatic conditions. These comparative findings highlight that vulnerability in rainfed rice systems is shaped not only by climatic exposure but also by region-specific socioeconomic factors. Accordingly, climate-responsive agricultural policies should be tailored to different regions, emphasizing improved extension services, access to climate and market information, adaptive training, and livelihood diversification to enhance the resilience of rainfed rice farmers.

**Keywords:** Adaptive capacity, climate change, farmer resilience, Livelihood Vulnerability Index, rainfed rice

## INTRODUCTION

Rice is the staple food for most of Indonesia's population, making rice farming central to national food security and the rural livelihoods of its people. Across Southeast Asia, rainfed rice systems are widely practiced, particularly in regions with limited irrigation infrastructure, and support millions of smallholder farmers. However, their strong dependence on rainfall renders productivity highly vulnerable to climatic variability, exposing farmers to yield decline and income instability when water availability is disrupted (Makuvara et al. 2022). In Indonesia, where rainfed rice farming remains prevalent, climate change has intensified these vulnerabilities.

Climate change in Southeast Asia is characterized by rising temperatures, altered rainfall patterns, prolonged droughts, and increasing pest infestations that threaten agricultural systems and rural livelihoods. In Indonesia, these impacts are reflected in an average temperature increase of approximately  $0.1^{\circ}\text{C}$  over the past three decades, accompanied by increasing rainfall variability and more frequent extreme weather events (Dharmawan 2021). Scientifically, climate change results from both natural and anthropogenic factors, including variations in solar

radiation, orbital elements, natural processes, and human activities, leading to long-term alterations in weather patterns and average climate conditions (Abdollahbeigi 2020; Muluneh 2021). These changes exert growing pressure on agricultural production systems that depend directly on natural climatic conditions (Compton 2023).

Empirical evidence from Indonesia and other Southeast Asian countries suggests that climate change has intensified production risks for rainfed farmers, including floods, droughts, crop failures, and pest outbreaks, thereby undermining agricultural productivity and household welfare (Ayinla et al. 2024). Similar patterns have been observed across rainfed rice systems in Southeast Asia, where climate variability disrupts planting schedules, increases yield uncertainty, and exacerbates income instability. While these impacts are widely documented, many existing studies remain primarily descriptive, providing general vulnerability profiles without sufficiently examining how different components of vulnerability interact across regions with contrasting socioeconomic and agro-ecological conditions.

Rainfed rice systems are among the most climate-sensitive agricultural systems in Indonesia, exhibiting lower and more variable productivity than irrigated systems

due to uncertain water availability. Declining rainfall reliability and recurring droughts have become key drivers of yield reduction and income instability (Birka et al. 2024). Addressing these challenges requires strengthening farmer resilience, defined as the capacity of farming households to withstand, adapt to, and recover from climate-related stressors while sustaining livelihoods (Kuhmonen 2020). In rainfed systems, resilience is shaped by the interaction of exposure, sensitivity, and adaptive capacity, which are influenced by socioeconomic characteristics, access to resources, and livelihood strategies (Allart et al. 2024).

Several analytical frameworks have been developed to assess climate vulnerability and resilience, including the Climate Vulnerability Index (CVI), the Household Vulnerability Index (HVI), the Climate Resilience Index (CRI), and the Livelihood Vulnerability Index (LVI). Among these, the LVI is particularly suitable for rainfed rice systems because it integrates social, economic, physical, environmental, and institutional dimensions into a single composite framework, explicitly linking exposure, sensitivity, and adaptive capacity (Bahta and Nyaki 2024; Islam and Ghosh 2024). However, many LVI-based studies in Indonesia focus on single locations or provide vulnerability rankings without comparative analysis or explicit identification of dominant vulnerability drivers, limiting their relevance for targeted policy design.

Despite increasing attention to climate vulnerability research, empirical studies focusing on rainfed rice farmers at the sub-national level in Indonesia remain limited. This gap is especially evident in provinces with contrasting agro-ecological and socioeconomic conditions, such as Central Java and Yogyakarta. Both provinces are major rice-producing areas but face increasing pressures from climate variability, limited irrigation infrastructure, and diverse livelihood constraints. The absence of localized and comparative evidence constrains the effectiveness of climate adaptation policies for rainfed rice systems.

This study advances existing vulnerability research by providing a comparative sub-national assessment of rainfed rice farmers in Central Java and Yogyakarta. Beyond descriptive vulnerability scoring, it examines the relative contributions of exposure, sensitivity, and adaptive capacity, and identifies key socioeconomic factors associated with vulnerability in each province. By linking LVI components to region-specific vulnerability drivers, the study generates policy-relevant insights to support differentiated climate adaptation strategies aligned with Indonesia's climate adaptation agenda.

Accordingly, this study addresses three research questions: (i) What is the level of livelihood vulnerability of rainfed rice farmers in Central Java and Yogyakarta as measured by the LVI and its components? (ii) How do key socioeconomic factors shape adaptive capacity and sensitivity in each province? (iii) Which LVI components contribute most to overall vulnerability, and how do these contributions differ between provinces? Addressing these questions provides empirical evidence to inform climate-responsive agricultural policies that aim to strengthen the resilience of rainfed rice farming systems in Indonesia.

## MATERIALS AND METHODS

### Study area

The findings of this study are intended to support analytical rather than statistical generalization. The purposive sampling approach was employed to capture vulnerability dynamics specific to rainfed rice farmers operating under defined agro-ecological and institutional conditions, rather than to generate population-representative estimates for all farmers in Indonesia, especially in Central Java and Yogyakarta. As a result, the LVI outcomes should be interpreted as context-specific patterns illustrating interactions among exposure, sensitivity, and adaptive capacity within rainfed rice systems.

Sampling choices may influence both the level and distribution of LVI scores, as well as the strength of observed associations in the correlation analysis. By focusing on farmers who rely solely on rainfall and lack access to technical irrigation, the study emphasizes vulnerability processes inherent to rainfed systems. It may yield higher sensitivity or exposure values than more heterogeneous samples. Similarly, correlation results reflect associations within this defined group and should be interpreted as indicative rather than causal relationships. Accordingly, the findings are most appropriately generalized to rainfed rice systems with comparable agro-ecological and socioeconomic characteristics, thereby contributing to theory building and policy learning rather than statistical inference.

### Procedures

#### *Data collection*

This study employed a purposive sampling approach, targeting farmers who engage in rainfed rice cultivation on land without technical irrigation infrastructure and rely exclusively on rainfall as their primary water source. Farmers with access to alternative water sources, such as wells, water pumps, or semi-technical irrigation systems, were excluded to ensure that the sample accurately reflected the conditions of rainfed rice farming. Although this non-probabilistic sampling strategy may limit external validity due to the absence of random selection, it is appropriate for research focusing on specific livelihood systems and climate exposure contexts. Consequently, the findings are not intended to be statistically representative of all rice farmers in Central Java and Yogyakarta (Table 1). Still, they are analytically generalizable to rainfed rice farming communities operating under comparable agro-ecological and climatic conditions.

Data were collected through structured household interviews with household heads using a pre-tested questionnaire. The survey was conducted between June and August 2025, a period selected to capture farmers' recent experiences and perceptions of climate variability. A total of 300 respondents were interviewed, with 50 respondents selected from each of the six study districts. Before the primary survey, the questionnaire was pre-tested to assess clarity, relevance, and internal consistency. Reliability testing was conducted using internal consistency analysis

to ensure the robustness of indicators across social, economic, physical, environmental, and institutional dimensions. Indicators with low consistency were revised before final data collection.

Ethical considerations were addressed before data collection. Verbal informed consent was obtained from all respondents after providing a clear explanation of the study's objectives, the voluntary nature of participation, the confidentiality of responses, and the right to withdraw at any time. Interviews were conducted by trained university students who received guidance on research objectives, survey instruments, ethical protocols, and standardized interviewing techniques. This approach minimized interviewer bias, enhanced consistency in data collection, and ensured that the data were reliable and suitable for constructing the Livelihood Vulnerability Index (LVI).

#### *Sampling procedure*

Purposive sampling was employed to select rainfed rice farmers who are directly exposed to climate variability and therefore relevant for assessing livelihood vulnerability using the Livelihood Vulnerability Index (LVI) (Table 2). This approach enhances internal validity by ensuring that respondents share comparable production characteristics and climate exposure. However, as purposive sampling is non-probabilistic, the findings are not intended for statistical generalization to all rice farmers in Indonesia. Instead, the results provide analytical generalization by offering context-specific insights into vulnerability and adaptive capacity among rainfed rice farmers.

A total of 300 farm households were surveyed, which is considered adequate for index-based vulnerability analysis

and multivariate statistical assessment while maintaining field feasibility. The sample was stratified at the district level across six study districts to ensure proportional representation of rainfed rice farmers from areas with distinct agro-ecological conditions, including differences in rainfall patterns, topography, and access to irrigation. This stratification strengthens the robustness of the comparative analysis across provinces.

The Livelihood Vulnerability Index (LVI) in this study employs an equal-weighting scheme across indicators to maintain methodological consistency and comparability with previous LVI-based studies. Nevertheless, it is acknowledged that alternative weighting approaches, such as expert-based or data-driven methods, may influence the relative contribution of individual indicators and, consequently, the magnitude of the index values. Despite this potential sensitivity, the overall vulnerability patterns and relative comparisons across study areas are expected to remain broadly consistent due to the theoretically grounded selection of indicators.

**Table 1.** Data collection

Province	District	$\Sigma$
Central Java	Klaten	50
	Karanganyar	50
	Boyolali	50
	Wonogiri	50
Yogyakarta	Gunungkidul	50
	Bantul	50
Total		300

**Table 2.** Livelihood Vulnerability Index

Main component	Indicator	Measurement method / Question	Measurement scale	Indicator type
Social	Education level of household head	Number of years of formal education completed	1 - 5	Inverse (-)
	Access to information	Frequency of attending agricultural extension activities or training sessions in the past year	1 - 5	Inverse (-)
Economic	Social networks	Participation in farmer groups or community organizations	1 - 5	Inverse (-)
	Ownership of productive assets	Types and number of agricultural tools or equipment owned	1 - 5	Inverse (-)
	Sources of income	Number and diversity of household income sources	1 - 5	Inverse (-)
Physical	Access to credit	Availability of access to formal or informal financial institutions	1 - 5	Inverse (-)
	Availability of production inputs	Ease of obtaining seeds, fertilizers, and farming equipment	1 - 5	Inverse (-)
	Access to irrigation	Type of water source used for irrigation (technical, non-technical, rainfed)	1 - 5	Direct (+)
Environmental	Access to infrastructure	Distance to markets, main roads, and agricultural facilities	1 - 5	Inverse (-)
	Exposure to climate change	Farmers' perception of changes in rainfall and temperature over the past 10 years	1 - 5	Inverse (-)
	Frequency of droughts	Number of drought events experienced in the past 5 years	1 - 5	Inverse (-)
Institutional	Environmental impacts on agriculture	Types and frequency of environmental disturbances (pests, floods, landslides)	1 - 5	Inverse (-)
	Access to assistance programs	Participation in government or NGO programs related to food security or climate adaptation	1 - 5	Inverse (-)
	Policy support	Farmers' perception of government policy support toward smallholder farmers	1 - 5	Inverse (-)

The classification of vulnerability levels into low, medium, and high categories is used as an analytical tool to facilitate comparative interpretation, rather than as absolute measures of vulnerability. These categories are context-specific and intended to support relative assessment within the study area.

### Data analysis

The Livelihood Vulnerability Index (LVI) was employed to assess the vulnerability of rainfed rice farmers to climate-related and socioeconomic stressors (Regasa and Kebede 2024). The LVI framework integrates multiple indicators into three core dimensions: exposure (E), sensitivity (S), and adaptive capacity (A), in line with established vulnerability assessment literature (Islam and Ghosh 2024) and (Bahta and Nyaki 2024).

At the indicator level, all variables were normalized using a min-max transformation to ensure comparability across different measurement units:

$$X'_i = \frac{X_i - X_{min}}{X_{max} - X_{min}}$$

Where  $X'_i$  denotes the normalized value of indicator  $i$ , and  $X_{min}$  and  $X_{max}$  represent the minimum and maximum observed values of the indicator, respectively. This transformation scales all indicators to a range between 0 and 1. For direct indicators, higher values indicate greater vulnerability, whereas for inverse indicators, higher values indicate lower vulnerability.

Dimension-specific indices were calculated as the arithmetic mean of their normalized indicators:

$$LVI_d = \frac{\sum X'_i}{n}$$

Where  $LVI_d$  represents the index value of dimension  $d$  (exposure, sensitivity, or adaptive capacity), and  $i$  is the total number of indicators within that dimension.

The overall LVI was computed as a weighted average of the three main dimensions:

$$LVI = w_E \times LVI_E + w_S \times LVI_S + w_A \times LVI_A$$

In this study, equal weighting was applied, assuming that all dimensions and indicators contribute equally to overall vulnerability. Accordingly, the weight for each dimension was calculated as:

$$w_x = \frac{1}{n}$$

In this study, equal weighting was applied to all dimensions and indicators to ensure methodological transparency and comparability with previous LVI-based studies, particularly in the absence of a clear empirical basis for differential weighting (Bahta and Nyaki 2024; Islam and Ghosh 2024). While alternative weighting schemes, such as expert-based or data-driven approaches, may influence the magnitude of LVI values, the relative vulnerability patterns are expected to remain broadly consistent due to the theoretically grounded selection of indicators. The resulting LVI values range from 0 to 1, with higher values indicating greater vulnerability, and were classified into low (0.00-0.33), medium (0.34-0.66), and high (0.67-1.00) categories for analytical comparison rather than as absolute measures of vulnerability (Regasa and Kebede 2024). Subsequently, a two-tailed Pearson

correlation analysis was conducted to examine associations, not causal relationships, between farmer's socioeconomic characteristics (age, education level, farming experience, household size, and income) and the LVI. Pearson's correlation was selected given the continuous nature and approximate normality of the variables, with statistical significance assessed at the 5% level. Future studies may employ multivariate approaches, such as regression analysis, to further investigate the determinants of livelihood vulnerability.

## RESULTS AND DISCUSSION

### Respondents characteristics

Table 3 presents the socioeconomic characteristics of rainfed rice farmers in Central Java and Yogyakarta. The sample was predominantly male, with female respondents representing a smaller proportion of the total, reflecting the gender composition commonly observed in smallholder rice farming systems in Indonesia (Quisumbing and Doss 2021). The average age of respondents was in the mid-50s, with most farmers concentrated in the 46-58 and 59-71 year age groups, indicating a dominance of middle-aged and older farmers. This age structure is consistent with previous findings that highlight aging trends in agricultural labor in developing agrarian context (Akdemir et al. 2021; He et al. 2022).

Educational attainment among respondents was generally low. Most farmers had completed elementary or senior high school, while only a limited proportion reported tertiary education. A notable share of respondents, particularly in Central Java, reported no formal education. Similar patterns of educational disparity among rainfed farming households have been documented in earlier studies, emphasizing education as a key socioeconomic characteristic in agrarian vulnerability contexts (Thinda et al. 2020). Farming experience was relatively extensive, with the majority of respondents reporting more than 15 years of experience in rice cultivation, suggesting long-term dependence on rainfed farming systems (Skendzić et al. 2021; Nigus et al. 2024).

Household size was predominantly moderate, with most respondents living in households of 4 to 6 members, while larger households were relatively uncommon. Regarding income, respondents were primarily concentrated in lower-income categories, and only a small proportion reported higher income levels (Singh et al. 2023). Comparable income structures among rainfed farming communities have been reported in previous livelihood studies, reflecting limited economic diversification in such systems (Manyanga et al. 2022).

Overall, these characteristics, particularly education level, household size, farming experience, and income, provide essential descriptive context for understanding the livelihood conditions of rainfed rice farmers and serve as a foundation for subsequent vulnerability analysis (Seigerman et al. 2024).

### Climate change perception

Farmers' perceptions of climate change are subject to recall bias and other cognitive biases, as recent experiences and local farming conditions shape them. Nevertheless, perception-based data remain essential for vulnerability assessments because they reflect how farmers interpret and respond to climate risks affecting production decisions (Estiningtyas et al. 2021). In both provinces, farmers reported rising temperatures, erratic rainfall, prolonged droughts, and increasing pest attacks, patterns that are broadly consistent with observed climate trends in Indonesia, including rising temperatures and rainfall variability (Table 4). However, meteorological data were not analyzed in this study. Regionally, Central Java farmers more frequently reported prolonged droughts and pest outbreaks, indicating greater exposure to water scarcity and biotic stress, whereas Yogyakarta farmers emphasized rising temperatures and unpredictable rainfall, suggesting

greater exposure to climatic variability within the LVI framework.

### Livelihood Vulnerability Index

Social networks constitute a critical component of community resilience, as strong social ties facilitate collective action, information sharing, and access to support during climate-related shocks (Hidalgo et al. 2022). Communities with active farmer groups and local organizations are generally better equipped to cope with and recover from disturbances such as droughts and production losses (Olowe et al. 2023). Livelihood Vulnerability Index category can be seen in Table 5. In Central Java, relatively stronger social and institutional engagement contributes to higher adaptive capacity, particularly through better access to extension services and coordinated farming activities (Table 6).

**Table 3.** Characteristics of rainfed rice farmers in Central Java and Yogyakarta, Indonesia

Characteristic		Central Java (N: 200)		Yogyakarta (N: 100)		Total (N: 300)	
		Σ	%	Σ	%	Σ	%
Gender	Male	178	89.00	73	73.00	251	83.67
	Female	22	11.00	27	27.00	49	16.33
Age (year)	20 - 32	11	5.50	5	5.00	16	5.33
	33 - 45	39	19.50	26	26.00	65	21.67
	46 - 58	56	28.00	44	44.00	100	33.33
	59 - 71	78	39.00	19	19.00	97	32.33
	72 - 84	16	8.00	6	6.00	22	7.33
Mean ± SD		55.91±12.88		55.18±11.36		54.29±12.59	
Education	No education	17	8.50	3	3.00	20	6.67
	Elementary School	71	35.50	51	51.00	122	40.67
	Junior High School	30	15.00	18	18.00	48	16.00
	Senior High School	69	34.50	26	26.00	95	31.67
	Bachelor's Degree	9	4.50	1	1.00	10	3.33
	Diploma	10	5.00	0	0.00	10	3.33
Experience (year)	1 - 14	66	33.00	23	23.00	89	29.67
	15 - 28	51	25.50	36	36.00	87	29.00
	29 - 42	37	18.50	28	28.00	65	21.67
	43 - 56	36	18.00	10	10.00	46	15.33
	57 - 70	10	5.00	3	3.00	13	4.33
Family member	< 3	97	48.50	40	40.00	137	45.67
	4 - 6	101	50.50	58	58.00	159	53.00
	> 6	2	1.00	2	2.00	4	1.33
Mean ± SD		3.46±1.27		3.74±1.23		3.55±1.26	
Income (IDR)	1,000,000 - 4,700,000	100	50.00	60	60.00	160	53.33
	4,700,001 - 8,400,000	58	29.00	28	28.00	86	28.67
	8,400,001 - 12,100,000	23	11.50	10	10.00	33	11.00
	12,100,001-15,800,000	13	6.50	2	2.00	15	5.00
	15,800,001- 19,500,000	6	3.00	0	0.00	6	2.00

**Table 4.** Climate change as experienced by farmers

Climate change	Central Java		Yogyakarta		Σ	%
	Σ	%	Σ	%		
Temperatures are getting hotter	76	18.36	51	29.14	127	21.56
Rainfall is unpredictable	120	28.99	61	34.86	181	30.73
Droughts are getting longer	101	24.40	26	14.86	127	21.56
Pest attacks are increasing	98	23.67	37	21.14	135	22.92
Others	19	4.59	0	0.00	19	3.23
Total	414	100.00	175	100.00	589	100.00

Note: Respondents were allowed to select more than one option; therefore, the total number exceeds 300

Correlation analysis of key household characteristics, including age, education, farming experience, family size, and income, provides essential insights into factors influencing farmers' adaptive capacity, as presented in Table 7. Education and skills of household heads further shape adaptive capacity by enhancing farmers' ability to interpret climate information and adopt appropriate adaptation strategies (Chapagain et al. 2025). Differences in educational attainment between Central Java and Yogyakarta help explain variations in adaptive responses, as lower levels of formal education may constrain farmers' ability to respond effectively to increasing climate stress, especially in more climate-sensitive environments.

Agriculture remains a primary source of livelihood for rural households in Indonesia, making farmers highly sensitive to disruptions in production inputs, markets, and irrigation access (Triyono et al. 2024). Within the LVI framework, this sensitivity is particularly evident in Yogyakarta, where limited irrigation infrastructure and strong dependence on rainfed systems heighten vulnerability. Environmental conditions, including rainfall variability and land characteristics, directly influence livelihood outcomes and increase exposure to climate risks (Nong et al. 2022).

Institutional support also plays a decisive role in shaping vulnerability. Communities with active government programs and farmer organizations

demonstrate greater coordination in managing climate risks and post-shock recovery processes (Eftekhari 2022). The interaction among adaptive capacity, sensitivity, and exposure ultimately determines overall vulnerability (Islam et al. 2025). Although both provinces fall within a medium vulnerability category, this should not be interpreted as a stable condition. Instead, it reflects a substantial level of climate risk in rainfed rice systems.

In Yogyakarta, vulnerability is driven primarily by high sensitivity, rather than exposure alone (Table 6). Key indicators contributing to sensitivity include reliance on rainfall for irrigation, frequent production disturbances over short periods, and limited flexibility in adjusting farming practices. Prolonged dry seasons and intensified rainfall variability further exacerbate these constraints, reducing adaptive options and increasing livelihood risk (Ratnasari et al. 2023; Namgyal et al. 2025). Recent observations of longer dry periods combined with shorter but more intense rainy seasons reinforce these exposure-sensitivity interactions (Rahayu et al. 2024).

Overall, the comparison highlights that differences in livelihood vulnerability between Central Java and Yogyakarta are shaped more by sensitivity and adaptive capacity than by exposure alone, underscoring the need for targeted, location-specific adaptation strategies in rainfed rice systems.

**Table 5.** Livelihood Vulnerability Index category

Indicator	Question	Index
Social	My education has equipped me to manage a farming business effectively.	A
	I obtain agricultural and weather information from extension workers, farmer groups, or local media.	A
	I have a strong social network (farmer groups, cooperatives, village communities).	A
Economic	I have sufficient agricultural assets (land, livestock, tools, savings)	A
	I have additional sources of income besides rice farming	S
Physical	I have access to agricultural credit or capital loans (e.g., KUR, cooperatives).	A
	Access roads and markets around my land are in good condition	A
	I rely solely on rain because there is no technical irrigation on my land.	S
Environmental	I have my own agricultural tools, such as a plow, water pump, and sprayer.	A
	I often experience extreme weather changes in a short period of time.	E
	Droughts have occurred in recent seasons, affecting my harvest.	E
Institutional	The surrounding environment (floods, landslides, pests) has an impact on my agricultural land.	E
	I have received assistance from government programs (seeds, fertilizer, training).	A
	My farmer group actively organizes activities, including training sessions and farmer meetings.	A

Note: A: Adaptive Capacity, S: Sensitivity, E: Exposure

**Table 6.** Result of Livelihood Vulnerability Index analysis

Province	Adaptive capacity (A)	Category A	Sensitivity (S)	Category S	Exposure (E)	Category E	LVI	Category LVI
Central Java	0.36	Medium	0.58	Medium	0.27	Low	0.40	Medium
Yogyakarta	0.39	Medium	0.68	High	0.32	Low	0.46	Medium

**Table 7.** Correlation factor

		Age	Education	Experience	Family member	Income
Central Java	Correlation coefficient	-.058	.230	-.056	.187	-.063
	Sig (2-tailed)	.416	.001	.428	.008	.376
	N	200	200	200	200	200
Yogyakarta	Correlation coefficient	.194	-.134	.255	.066	.101
	Sig (2-tailed)	.053	.177	.010	.516	.318
	N	100	100	100	100	100

## Discussion

More than 80.00% of rainfed rice farmers in Central Java and Yogyakarta are male, reflecting gendered labor allocation and decision-making structures in rainfed rice farming systems (Medagbe et al. 2020). While gender itself is not treated as a direct driver of vulnerability in the LVI, it represents a structural characteristic that shapes access to resources, labor availability, and household decision processes. Most farmers fall within the productive age range of 46-58 years (Khairunnisa et al. 2025), a demographic profile that is commonly associated with accumulated farming experience. From a resilience perspective, this age group reflects an interaction between individual adaptive capacity, through knowledge and social capital and structural vulnerability, as physical constraints may increase sensitivity to climate stressors. Approximately 40.00% of farmers have completed only primary education, indicating limited human capital that is structurally associated with reduced access to climate information and adaptive knowledge (Table 3).

Differences in farming experience between Central Java and Yogyakarta further illustrate the distinction between structural vulnerability and individual adaptive capacity. Longer farming experience in Yogyakarta (29-42 years) reflects accumulated local knowledge; however, its positive association with higher LVI values suggests that experience alone does not necessarily translate into greater adaptive capacity. Within the LVI framework, farming experience functions as a proxy indicator and may not fully capture qualitative dimensions such as learning intensity or openness to innovation (Osabohien et al. 2024). Household size, supported directly by the data, represents a structural vulnerability factor, as larger households (4-6 members, 53.00%) are associated with higher dependency ratios and resource pressure, potentially constraining adaptive options (Bitana et al. 2024). Similarly, household income levels clustered between IDR 1,000,000 and 4,700,000 indicate limited financial capacity, although income indicators alone may not reflect informal support mechanisms or non-monetary coping strategies (Aleksandrova et al. 2024).

Climate exposure, as captured through farmers' perceptions, reflects experienced climate stress rather than objectively measured conditions. In Central Java, frequent reports of drought and pest attacks are associated with exposure to water scarcity and biotic stress, which affect rice production (Wang et al. 2024). In Yogyakarta, higher reports of rising temperatures and rainfall variability are associated with disruptions to planting schedules and production stability (Lê and Nguyen 2024) (Table 4). These patterns reinforce the role of structural exposure conditions, such as agro-ecological settings and rainfall dependency, rather than individual behavior alone. Sensitivity patterns further differentiate vulnerability profiles. The moderate Sensitivity score in Central Java reflects a balanced interaction between dependence on rainfall and available coping mechanisms, whereas the high Sensitivity score in Yogyakarta indicates stronger structural dependence on natural conditions and limited production flexibility Senapati (2020) (Table 4). Importantly, these sensitivity measures capture relative dependence rather

than dynamic short-term adjustments, such as seasonal labor shifts or informal coping responses.

Methodologically, the LVI provides a practical, integrative framework but also entails limitations that warrant reflection. Equal weighting of indicators may obscure the relative importance of specific drivers. In contrast, the use of proxy indicators (e.g., farming experience as a proxy for adaptive capacity) may oversimplify complex social processes (Bahta and Nyaki 2024). Correlation analysis further identifies associations rather than causal relationships, meaning that observed patterns should be interpreted as indicative vulnerability configurations rather than direct effects. These methodological considerations highlight the need to interpret LVI results as analytical tools for understanding relative vulnerability, rather than definitive measures of resilience or causality.

In conclusion, this study finds that vulnerability to climate change among rainfed rice farmers is shaped by the interaction between climate exposure and socioeconomic characteristics rather than environmental factors alone. The LVI reveals distinct vulnerability patterns between Central Java and Yogyakarta, driven mainly by differences in sensitivity and adaptive capacity. In Central Java, vulnerability is associated with education level and household size, while in Yogyakarta it is associated with farming experience, reflecting contrasting vulnerability configurations across provinces.

These findings suggest the need for context-specific adaptation approaches. In Central Java, strengthening practical climate literacy and household-level adaptive planning may help reduce sensitivity linked to human capital and dependency pressures. In Yogyakarta, enhancing adaptive capacity may require a learning-oriented extension that enables farmers to adjust long-established practices to changing climatic conditions. These implications should be interpreted cautiously, as the results indicate associations rather than causal relationships.

Methodologically, this study highlights limitations related to perception-based indicators, proxy variables, and equal weighting within the LVI framework. Future research should refine vulnerability assessments by incorporating dynamic indicators, alternative weighting schemes, and longitudinal or mixed-methods approaches to capture adaptation processes in rainfed rice systems better.

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## REFERENCES

- Abdollahbeigi M. 2020. Non-climatic factors causing climate change. *J Chem Rev* 2 (4): 292-308. <https://doi.org/10.22034/jcr.2020.249615.1087>.
- Akdemir Ş, Koungnan EA, Keskin F, Akçaöz HV, Boz İ, Kutlar İ, Miassi YE, Küsek G, Türker M. 2021. Ageing population and agricultural sustainability issues: Case of Turkey. *New Medit* 20 (4): 49-62. <https://doi.org/10.30682/nm2104d>.
- Aleksandrova O, Azadi H, Värnik R, Nurmet M, Viira AH. 2024. Determinants of farm income variability: Evidence from Estonia. *Ger J Agric Econ* 73 (3): 1-26. <https://doi.org/10.52825/gjae.v73i3.2549>.
- Allart L, Joly F, Oostvogels V, Mosnier C, Gross N, Ripoll-Bosch R, Dumont B. 2024. Farmers' perceptions of permanent grasslands and their intentions to adapt to climate change influence their resilience strategy. *Renew Agric Food Syst* 39: e33. <https://doi.org/10.1017/S1742170524000279>.
- Ayinla RA, Alao O, Adesoji S, Ayinla RA, Olawuyi SO. 2024. Perceived effects of climate change on farm income: Insights from smallholder arable crops farmers in South-West Nigeria. *Yuzuncu Yil Univers J Agric Sci* 34 (4): 608-620. <https://doi.org/10.29133/yyutbd.1501494>.
- Bahta YT, Nyaki SA. 2024. Livelihood vulnerability from drought among smallholder livestock farmers in South Africa. *Hydrology* 11 (9): 137. <https://doi.org/10.3390/hydrology11090137>.
- Birka RJ, Jude Kawzu K, Nnaji CC. 2024. Climate change adaptation through rainwater harvesting to enhance food security in Diamaré, Cameroon. *J Water Sanit Hyg Dev* 14 (12): 1243-1259. <https://doi.org/10.2166/washdev.2024.120>.
- Bitana EB, Lachore ST, Utallo AU. 2024. The influence of household size on socioeconomic conditions of rural farm households in Southern Ethiopia. *Cogent Soc Sci* 10 (1): 2358153. <https://doi.org/10.1080/23311886.2024.2358153>.
- Chapagain PS, Banskota TR, Shrestha S, Khanal NR, Yili Z, Yan J, Linshan L, Paudel B, Rai SC, Islam MN, Poudel KR. 2025. Studies on adaptive capacity to climate change: A synthesis of changing concepts, dimensions, and indicators. *Humanit Soc Sci Commun* 12 (1): 331. <https://doi.org/10.1057/s41599-025-04453-3>.
- Compton MT. 2023. Food insecurity as a social determinant of mental health. *Psych Annal* 44 (1): 46-51. <https://doi.org/10.3928/00485713-20140108-08>.
- Dharmawan IWS. 2021. Mitigation and adaptation of climate change disaster. *IOP Conf Ser Earth Environ Sci* 874 (1): 012005. <https://doi.org/10.1088/1755-1315/874/1/012005>.
- Eftekhari MS. 2022. Impacts of climate change on agriculture and horticulture. In: Bandh SA (eds). *Climate Change: The Social and Scientific Construct*. Springer, Cham. [https://doi.org/10.1007/978-3-030-86290-9\\_8](https://doi.org/10.1007/978-3-030-86290-9_8).
- Estiningtyas W, Suciandini, Dermoredjo SK. 2021. Characteristics and Farmer's Response to Climate Variability to Support Sustainable Agriculture in West Java. *IOP Conf Ser Earth Environ Sci* 653 (1): 012004. <https://doi.org/10.1088/1755-1315/653/1/012004>.
- He J, Feng P, Wang B, Zhuang, Zhang Y, Liu DL, Cleverly J, Huete A, Yu Q. 2022. Centennial annual rainfall pattern changes show an increasing trend with higher variation over Northern Australia. *J Hydrometeorol* 23 (8): 1333-1349. <https://doi.org/10.1175/jhm-d-21-0116.1>.
- Hidalgo HA, Cuesta MA, Razafindrabe BHN. 2022. Street vendors' livelihood vulnerability to typhoons in Philippines. *Philipp J Sci* 151 (6): 2191-2202. <https://doi.org/10.56899/151.6a.11>.
- Islam A, Ghosh S, Sarkar M. 2025. Assessing livelihood vulnerability of rural communities in the wake of recurrent tropical flood hazards in India. *Natur Hazards* 121 (1): 677-704. <https://doi.org/10.1007/s11069-024-06847-z>.
- Islam A, Ghosh S. 2024. A comparison of performance measures of two livelihood vulnerability indices in the context of recurrent tropical flood hazards. *Natur Hazards Res* 4 (3): 498-506. <https://doi.org/10.1016/j.nhres.2023.12.011>.
- Khairunnisa F, Rahayu L, Rozaki Z, Rubiyanto CW. 2025. Impact of inpari nutri zinc rice on farmer welfare and food security in Indonesia. *Res World Agric Econ* 6 (2): 225-243. <https://doi.org/10.36956/rwae.v6i2.1644>.
- Kuhmonen I. 2020. The resilience of Finnish farms: Exploring the interplay between agency and structure. *J Rural Stud* 80: 360-371. <https://doi.org/10.1016/j.jrurstud.2020.10.012>.
- Lê S, Nguyen HH. 2024. Livelihood vulnerability to climate change of casava smallholders in central highlands of Vietnam. *For Soc* 8 (2): 422-442. <https://doi.org/10.24259/fs.v8i2.32230>.
- Makuvura Z, Marumure J, Chidoko P. 2022. Effects of different seed pre-treatments on enhancing germination of selected indigenous plant species in Zimbabwe. In: Poshiwa X, Ravindra Chary G (eds). *Climate Change Adaptations in Dryland Agriculture in Semi-Arid Areas*. Springer, Singapore. [https://doi.org/10.1007/978-981-16-7861-5\\_19](https://doi.org/10.1007/978-981-16-7861-5_19).
- Manyanga M, Murendo C, Pedzisa T, Mutyasira V, Ndou R. 2022. Resilience capacities and implications for food security in Zimbabwe. *Afr J Agric Resour Econ* 17 (4): 298-312. [https://doi.org/10.53936/afjare.2022.17\(4\).20](https://doi.org/10.53936/afjare.2022.17(4).20).
- Mulunch MG. 2021. Impact of climate change on biodiversity and food security: A global perspective a review article. *Agric Food Secur* 10 (1): 36. <https://doi.org/10.1186/s40066-021-00318-5>.
- Medagbe FM, Komatsu S, Mujawamariya G, Saito K. 2020. Men and women in rice farming in Africa: A cross-country investigation of labor and its determinants. *Front Sustain Food Syst* 4: 117. <https://doi.org/10.3389/fsufs.2020.00117>.
- Namgyal P, Sarkar S, Kumar R, Dolkar T, Rawat V. 2025. Assessment of livelihood vulnerability across different altitudinal zones under the influence of a changing climate in the Trans-Himalayan region. *Natur Hazards* 121: 17045-17065. <https://doi.org/10.1007/s11069-025-07463-1>.
- Nigus HY, Mohnen P, Nillesen E. 2024. Market experience and agricultural technology adoption: The role of risk aversion and locus of control. *Eur Rev Agric Econ* 51 (5): 1312-1347. <https://doi.org/10.1093/erae/jbae033>.
- Nong HTT, Gan C, Hu B. 2022. Livelihood vulnerability to climate change: A case of farm households in Northeast Vietnam. *Environ Develop Sustain* 24 (10): 12059-12078. <https://doi.org/10.1007/s10668-022-02201-0>.
- Olowe OS, Jacinto HS, Limbago JS, Folorunso EA, Sarfo I, Brown C. 2023. Assessing social vulnerability to climate change in a fishery-dependent village in south central Vietnam. *Environ Natur Resour J* 21 (5): 390-401. <https://doi.org/10.32526/ennrj/21/20230027>.
- Osabohien R, Jaaffar AH, Matthew O, Osabuohien E, Adeleke OK, Olonade OY, Okoh GO, Khalid AA. 2024. Soil management practice and smallholder agricultural productivity in Nigeria. *Discov Sustain* 5 (1): 283. <https://doi.org/10.1007/s43621-024-00467-0>.
- Quisumbing AR, Doss CR. 2021. Gender in agriculture and food systems. *Handb Agric Econ* 5: 4481-4549. <https://doi.org/10.1016/bs.hesagr.2021.10.009>.
- Rahayu L, Putri SE, Rozaki Z, Triyono. 2024. Climate change adaptation in red rice farming of Segreng and Inpari 24 varieties in Indonesia. *BIO Web Conf* 119: 05005. <https://doi.org/10.1051/bioconf/202411905005>.
- Ratnasari ED, Susilowati I, Maria NSB. 2023. Analysis of the vulnerability of farmers' livelihoods as an impact of shifting slow variables and fast variables: Livelihood Vulnerability Index and photovoice approaches. *Rev Gestao Soc Ambiental* 17 (8): 1-19. <https://doi.org/10.24857/rgsa.v17n8-007>.
- Regasa S, Kebede J. 2024. Vulnerability to climate change and variability: Gender and agro-ecological perspectives. *Clim Chang* 177 (8): 120. <https://doi.org/10.1007/s10584-024-03764-9>.
- Seigerman CK, Leite NS, Martins ESPR, Nelson DR. 2024. At the extremes: Assessing interrelations among the impacts of and responses to extreme hydroclimatic events in Northeast Brazil. *J Hydrol* 632: 130850. <https://doi.org/10.1016/j.jhydrol.2024.130850>.
- Senapati AK. 2020. An indicator-based approach to assess farm households' vulnerability to climate change: Evidence from Odisha, India. *Spat Inf Res* 28 (2): 139-157. <https://doi.org/10.1007/s41324-019-00277-x>.
- Singh P, Singh S, Dubey RS. 2023. Climate change impacts on agriculture: Crop productivity and food security. In: Fulekar MH, Dubey RS (eds). *Climate Change and Sustainable Development*. CRC Press, Boca Raton. <https://doi.org/10.1201/9781003205548-4>.
- Skendžić S, Zovko M, Živković IP, Lešić V, Lemić D. 2021. The impact of climate change on agricultural insect pests. *Insects* 12 (5): 440. <https://doi.org/10.3390/insects12050440>.
- Thinda KT, Ogundeji AA, Belle JA, Ojo TO. 2020. Understanding the adoption of climate change adaptation strategies among smallholder farmers: Evidence from land reform beneficiaries in South Africa. *Land Use Pol* 99: 104858. <https://doi.org/10.1016/j.landusepol.2020.104858>.

- Triyono T, Al Qudsi MFF, Rahmawati N, Rozaki Z, Kamarudin MF. 2024. The role of organic rice farm income on farmer household welfare: Evidence from Yogyakarta, Indonesia. *Open Agric* 9 (1): 20220273. <https://doi.org/10.1515/opag-2022-0273>.
- Wang H, Chen B, Shen X. 2024. Extreme rainfall, farmer vulnerability, and labor mobility: Evidence from rural China. *Sci Total Environ* 918: 170866. <https://doi.org/10.1016/j.scitotenv.2024.170866>.