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Livelihood Vulnerability and Resilience of Rice Farmers in Flood- and Pest-Affected Areas of Karawang Regency, West Java

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ABSTRACT

Despite Karawang Regency's strategic role as a major agricultural production center in West Java, recurring pest infestations and flooding have increasingly undermined farmers' livelihoods. On the other hand, empirical studies examining livelihood resilience at the household level remain limited, particularly within a sustainable livelihood framework. This research addresses this gap by analyzing the resilience of agricultural livelihoods in Kutawaluya District using a mixed-methods approach. Quantitative data were collected from 55 farming households affected by pest attacks, plant diseases, flooding, and drought, and were complemented by qualitative insights to enrich contextual understanding. Livelihood resilience was assessed using the Livelihood Vulnerability Index (LVI) across key livelihood assets. The results indicate that the ecological dimension exhibits the highest vulnerability, with an LVI value of 0.9, reflecting severe exposure to environmental stressors. However, strong social capital among farming households emerges as a critical mitigating factor that enhances resilience under precarious conditions. This study contributes to the livelihood resilience theory by demonstrating the compensatory role of social capital in contexts of high ecological vulnerability. Practically, the findings provide evidence-based guidance for policymakers and extension services to strengthen social networks and collective action as part of sustainable livelihood strategies in flood- and pest-prone agricultural regions.

Keywords: karawang, livelihood assets, livelihood resilience, livelihood vulnerability index, SLA

INTRODUCTION

Indonesia's agricultural sector remains central to national food security and rural socio-economic stability, with rice as the primary staple and core production commodity. The agricultural industry is a vital and strategic domain, interconnected with both the economic and social-political spheres. The agricultural industry in Indonesia is the primary producer of rice commodities and is a crucial component of the national agricultural framework, addressing the fundamental needs of the Indonesian populace, particularly in rural regions (Azhari & Nababan, 2021). Tola (2016) asserts that agriculture is a fundamental element sustaining the rural economy in Indonesia, enabling numerous farming households to thrive by relying on agricultural products to fulfill their requirements. The agricultural sector can contribute to economic growth in Indonesia if it, especially rice farming, possesses substantial multifunctional value in enhancing food security, boosting the welfare of farming households, and ensuring environmental sustainability (Kusumaningrum, 2019). The Ministry of Agriculture (2022) asserts that ensuring food security and sufficient food availability at the national or provincial level is a vital component of Indonesia's agricultural industry. Nonetheless, sufficient food availability at the national level does not inherently provide food security at the family and individual levels. The

availability of food, especially rice consumption, is determined by the extent of rice production (Putri, 2023). The agriculture sector faces challenges in enhancing productivity and efficiency from a production standpoint (Alta et al., 2023). The demand for paddy rice as a fundamental food staple in Indonesia is steadily rising alongside the expanding population (Astuti, 2017). According to data from Badan Pusat Statistik (BPS) in 2023, rice output from January to September 2023 totaled 45.33 million tons of dry grain (GKG), reflecting a decline of 0.11 million tons or 0.23% compared to the corresponding period in the previous year. Additionally, the rice cultivation area in Indonesia during January to September 2023 was 8.66 million hectares, reflecting a reduction of 0.03 million hectares relative to the corresponding time of the previous year. Karawang Regency, located in West Java Province, is a significant national rice granary and ranks as the second-largest rice producer following Indramayu Regency, contributing approximately 1,370,802 tons of GKP annually to meet national rice requirements (BPPD Karawang Regency, 2022).

Despite its strategic role in national policy, rice farming continues to face persistent constraints in productivity and efficiency, even in major granaries such as Karawang Regency, West Java. National data show declining production and harvested area trends in recent years, demonstrating the sector's difficulty in sustaining output growth while meeting rising domestic demand. Recurrent environmental stressors, especially floods and pest outbreaks exacerbate these production challenges. Flood events, driven by climate variability and inadequate drainage infrastructure, disrupt planting and harvesting cycles, reduce yields, and increase crop losses. Meanwhile, pest pressures such as rice field rat infestations further undermine rice cultivation by increasing damage and input costs, consistent with broader global evidence of climate-exacerbated pest impacts on staple crops. Recent analyses highlight how climate change intensifies both flood frequency and pest proliferation, leading to increased crop losses and heightened risk for vulnerable farming systems globally (Carrington, 2025). The Kutawaluya District, Karawang Regency characterized by its vast agricultural land, encompassed 4,372.00 hectares in 2021. The Kutawaluya District possesses significant economic potential, particularly within the agriculture sector, which is essential for the community's daily revenue. Income from the agricultural sector remains insufficient to fulfill the living requirements of farming households due to adverse effects that negatively influence farmers. One adverse effect impacting farmers' livelihoods is the occurrence of rat infestations and flooding disasters. The primary determinants of the rice field rat population are food availability, reproduction, and the presence of suitable shelter habitats (Sudarmaji & Herawati, 2017). Brown et al. (2003), as cited in Sudarmaji & Herawati (2017), shown that rice field rats inhabit irrigation embankments, village-adjacent embankments, roadways within rice fields, and central embankments in rice fields, exhibiting a broad foraging range to procure sustenance in their surroundings. Floods are a prevalent natural hazard in Indonesia, particularly in low-lying regions. Flooding transpires when a region or land becomes inundated as a result of elevated air volume attributed to climate change, along with the increasing frequency, shallowing, and constriction of river flows (Tommi & Dharmawan, 2016). The Kutawaluya District encountered floods caused by river water discharge from the Rengasdengklok District, attributed to intense rainfall, leading to groundwater saturation, a condition where water cannot permeate the soil. A further issue is the extensive number of towns constructed on the Citarum floodplain, compounded by drainage systems that have been shortened or rendered shallower. Alongside flooding, farmers in the Kutawaluya District encountered rat infestations that significantly hindered rice cultivation. These flood conditions are likely to result in crop loss and the onset of pest infestations on rice plants. Maulidah (2012) asserts that climate change, characterized by higher rainfall, leads to a decline in agricultural commodity productivity, culminating in shortages. The issues of floods and rat infestation provide a compelling rationale for one of the elements contributing to the downward trend of rice output in Kutawaluya District, Karawang Regency, observed during the past three years, specifically from 2020 to 2022. Table 1 presents data on land area, production, and productivity of rice harvests by district in Karawang Regency.

Table 1. Land Area, Annual Production, and Productivity of Rice Harvest in Kutawaluya District, 2020-2022

Year	Harvested Area (Ha)	Production (Ton)	Productivity (Ton/Ha)
2020	4.372	61.208	7,0
2021	4.372	60.655	6,9
2022	4.372	58.082	6,6

Source: Karawang Regency Communication and Information Service (2023)

According to Table 1 (Karawang Regency Communication and Information Service, 2023), Kutawaluya District has witnessed a decrease in rice production over the past three years, with most residents relying on rice farming, rendering them highly susceptible to fulfilling their household needs. Rice cultivation has numerous challenges that might impact household income. This encompasses variable rice prices and the observation that agricultural input costs generally rise at a rate beyond that of output prices (Ringo, 2023). These environmental pressures are translated directly into livelihood vulnerability for smallholder rice producers, especially those with limited access to capital, technology, and diversified income sources. Empirical studies from South and Southeast Asia show that vulnerability to floods and related hazards significantly constrains rural livelihoods, often resulting in low resilience indices among farming households. For example, assessments in Pakistan's flood-affected districts reveal generally low household resilience, while research in the Mekong Delta demonstrates differentiated vulnerability and resilience patterns among rice farming households facing drought and saltwater intrusion (Mulya & Hudalah, 2024). However, much of the existing literature tends to analyze ecological hazards, livelihood vulnerability, and resilience capacities in isolation or within separate disciplinary frameworks. This study addresses a clear gap by integrating the measurement of multi-dimensional vulnerability (ecological, social, economic), livelihood asset capacities (natural, physical, human, financial, social), and resilience outcomes within a unified framework tailored to agricultural communities experiencing both floods and pest pressures. As drawn on the Sustainable Livelihood Framework and linked Livelihood Vulnerability Index models, this research advances theoretical understanding of how asset endowments mediate vulnerability and resilience in high-risk agricultural contexts, and provides empirically grounded insights for targeted local adaptation strategies and risk-informed policy design.

Households and communities primarily engaged in agriculture face a greater risk of vulnerability and poverty compared to those whose main occupation is non-agricultural (Ersado, 2006). Frihy & El-Sayed (2012) define vulnerability as a system's incapacity to manage the detrimental impacts of climate change, encompassing climate variability and extreme weather conditions. Vulnerability analysis emphasizes the implications for the object itself as well as the primary and indirect effects on the surrounding environment. This pertains to the potential for alleviating these repercussions and enhancing the ability to handle future occurrences (Longstaff et al., 2010). Under crisis situations, agricultural households possess the livelihood capital necessary to attain resilience. Livelihoods can be enhanced by augmenting a household's productivity via agricultural intensification, skill development, improved access to infrastructure and markets (for both labor and goods), and diversification of employment from agricultural to non-agricultural industries, either locally or internationally. These chances create money to support sustainable livelihoods and enhance the household's socio-economic status or alleviate its poverty condition. Individuals in poverty typically devise ways to secure their necessities and mitigate hazards to their livelihoods. The crucial connection between poverty and livelihoods involves mitigating risks that impact livelihoods and achieving sustainable income streams to alleviate and ultimately escape the poverty cycle. Azzahra & Dharmawan (2015) assert that the propensity to employ capital will influence the fundamental support of agricultural households in their livelihood endeavors. Should the household's capital be compromised, its susceptibility during a crisis will escalate. Flooded rice fields and rat infestations adversely impact farmers' yields, potentially halving the crop, diminishing rice quality, and escalating agricultural costs for farmers. This leads to a reduction in farmers' income. The significant livelihood risk compels farming households in Kutawaluya District to adopt several measures for survival and economic enhancement, aiming for livelihood resilience (Brigita & Sihaloho, 2018).

Livelihood resilience denotes the capacity of an individual or household to confront, adjust to, and recuperate from diverse shocks and challenges while preserving their long-term potential to sustain or enhance their well-being. Livelihood resilience denotes the capacity of an individual or household to confront, adjust to, and recuperate from diverse shocks and challenges while preserving or enhancing long-term well-being. However, despite a growing body of research on vulnerability and resilience in agricultural contexts, most studies tend to examine environmental stressors such as floods or pest outbreaks in isolation, or focus solely on vulnerability without fully linking it to resilience outcomes. For example, recent work in Southern Punjab, Pakistan highlights both vulnerability and resilience to flood hazards among smallholder farming households but does not integrate livelihood asset capacities into the analysis of resilience pathways (Raza & Hatab, 2025). Similarly, studies in Sichuan Province, China and Hubei Province explore how livelihood strategies influence resilience under flood conditions, emphasizing adaptation capacity and livelihood buffering but remain largely focused on single hazard

types rather than multi-stress environments (Yang et al., 2021). While the Sustainable Livelihoods Approach (SLA) and Livelihood Vulnerability Index (LVI) have independently advanced our understanding of how households respond to climatic risks, there is a notable gap in research that integrates LVI with SLA to assess how multidimensional vulnerability interacts with livelihood asset capacities to shape overall resilience, particularly in regions experiencing concurrent ecological stressors such as flooding and pest infestations. Addressing this gap, the present study develops and applies a unified framework that jointly measures vulnerability (ecological, social, economic), livelihood asset endowments (natural, physical, financial, human, social), and resilience outcomes among rice farming households in flood- and pest-prone areas of Karawang Regency, offering both theoretical innovation and practical insights for sustainable livelihood strategies in high-risk agrarian settings.

Grand theory in this study refers to the main theoretical framework based on the Sustainable Livelihoods Approach (SLA) developed by Chambers and Conway (1992) and enriched by DFID guidelines (1999). This approach emphasizes that the sustainability of household livelihoods is determined by the ability to access and utilize five types of livelihood capital (natural, human, social, physical, and financial) adaptively to cope with pressures and disturbances. In the context of farmers in flood-prone areas, this interaction of capital becomes a determinant of household economic resilience in maintaining production activities and meeting living needs. Additionally, this research utilizes the resilience theory perspective, which emphasizes the ability of a socio-ecological system to endure (toughness), recover quickly (rapidity), and adapt to the dynamics of environmental change. Ecological disturbances such as floods and pest infestations can threaten livelihood sustainability if community adaptive capacity is low. Therefore, measuring livelihood resilience is important for understanding the resilience of the agrarian system at the community level. The approach is linked to the vulnerability framework (exposure, sensitivity, adaptive capacity), which is the basis for measuring the Livelihood Vulnerability Index (LVI). Thus, this study combines three major theoretical frameworks to gain a systematic understanding of how risks, livelihood assets, and adaptive capacity contribute to the resilience of farmer households.

The middle-range theory used in this study includes instruments and operational concepts that bridge grand theory with research variables. The Livelihood Vulnerability Index (LVI) is used to quantitatively measure the level of vulnerability through three sub-indices: ecological, social, and economic. These indicators reflect the level of exposure to floods and pests, household social conditions, and the economic stability of farmers. An LVI value approaching 1 indicates increasing vulnerability. Next, the livelihood capital pentagon serves as a tool to assess household asset capacity in supporting both agrarian activities and economic diversification strategies. In this study, it was found that social capital is a relatively strong asset as a risk buffer, while financial capital is the weakest component, exacerbating farmers' limitations in dealing with losses from floods and pest attacks. Finally, the study operationalized livelihood resilience through five dimensions: 1) the Toughness/Robustness of Livelihood, which denotes the degree to which the livelihood system can withstand shocks without losing its functionality. In a socio-ecological setting, this refers to the ability to withstand disturbances while preserving fundamental structures and functions (Folke et al., 2002; Walker et al., 2004), to assess the extent to which households are able to maintain their livelihoods, recover from shocks, and adjust production strategies. This approach provides a comprehensive overview of the strengths and weaknesses of the farmers' livelihood system in the study area, enabling more contextual policy recommendations.

Additionally, the rapidity of recovery serves as a crucial metric for assessing resilience. A resilient livelihood can swiftly recuperate from economic, environmental, and social disruptions (Cutter et al., 2008). The security of the livelihood system pertains to the assurance of meeting fundamental demands sustainably. Livelihood security encompasses reliable access to food, income, and other essential resources (Chambers & Conway, 1992). Stability of livelihood pertains to the enduring consistency and durability of the livelihood system throughout time. Avoiding susceptibility to seasonal and long-term fluctuations is crucial (Ellis, 2000). Flexibility to Adapt to Change refers to the capacity to modify livelihood strategies and resources in response to external factors, like climate change, market dynamics, or policy shifts (Folke et al., 2002; Walker et al., 2004). This study is to examine the vulnerability and resilience of the livelihoods of rice farmers in Kutawaluya District, Karawang Regency, based on the aforementioned issues.

METHODS

This research uses mix-methods. The quantitative method involves sampling from a population and employing a questionnaire for data collecting. The questionnaire comprises inquiries that facilitate the exploration of data and facts. The reliability test results show that the composite reliability values for all variables are >0.6, so they can be considered reliable. Additionally, the VIF values are >5, indicating no multicollinearity in explaining the influence of the independent variables, on the dependent variable. These results suggest that the questionnaire demonstrates strong internal consistency, indicating that the items effectively measure the intended constructs (Roberts et al., 2021).

Table 2. Cronbach's alpha and composite reliability value

	Cronbach's alpha	Composite reliability (rho_c)	Notes
HC	0.890	0.922	Reliable
NC	0.482	0.653	Reliable
SC	0.681	0.796	Reliable
PC	0.820	0.869	Reliable
FC	0.554	0.714	Reliable
LR	0.427	0.745	Reliable

Source: Primary data

Table 2. Cronbach's alpha and composite reliability value demonstrates that all variables possess a Cronbach's alpha value exceeding 0.6, signifying their reliability. A multicollinearity test was also conducted to ensure that there was no multicollinearity among the independent variables (HC, NC, SC, PC, and FC) in their influence on the dependent variable, Innovation Livelihood Resilience (LR).

Table 3. VIV value

	VIF	Notes
HC → LR	1,318	*Non Multicollinearity*
NC → LR	2,109	*Non Multicollinearity*
SC → LR	1,665	*Non Multicollinearity*
PC → LR	1,426	*Non Multicollinearity*
FC → LR	1,265	*Non Multicollinearity*

Source: Primary data

According to Table 3, Since the VIF for each variable is < 5, it does not violate the multicollinearity test. Qualitative data collection was conducted through in-depth interviews with informants. Informants were chosen utilizing the snowball sampling technique. There were 5 key informants, namely the village head, head of the farmer group, field agricultural extension worker, community leader, and head of the farmer group. Key informants were determined based on the need for qualitative data regarding agricultural conditions, problems, and potential owned by farmers in Kutawaluya District. A supplementary approach employed was field observation at the research site to see the actual phenomena and evaluating pertinent papers, including village monograph data. The primary data for this study was collected through a questionnaire. This study employed the Livelihood Vulnerability Index, Livelihood Sustainability, and Livelihood Resilience as analytical methods. Quantitative data analysis was used to describe the results of measuring LVI, livelihood assets, and livelihood resilience in the form of tables, diagrams, and graphs, which were then analyzed descriptively. Livelihood asset measurement used a questionnaire with a Guttman scale, which was then transformed into livelihood asset categories: low values (1.00 - 1.55); medium values (1.55 - 2.55); and high values (2.55 - 3.00). The secondary data acquired were utilized to augment and reinforce the primary data. Simultaneously, the processing of primary data was distinguished according to the study methodology and data classification. The data derived from the questionnaire results were analyzed utilizing Microsoft Excel 2019 and SPSS v25. Upon compilation of the data, verification and correction were conducted for inaccuracies. Qualitative data processing procedures were executed in four stages of analysis: data collection, data reduction, data presentation in descriptive format, and conclusion formulation. The data collection phase involves entering the study setting and gathering research data. The data reduction stage involves the selection, simplification, abstraction, and transformation of raw data derived from field notes. The notion of livelihood is illustrated by a pentagon comprising natural capital, social capital, physical capital,

financial capital, and human capital (DFID, 1999). The pentagonal configuration of assets is seen in Figure 1.

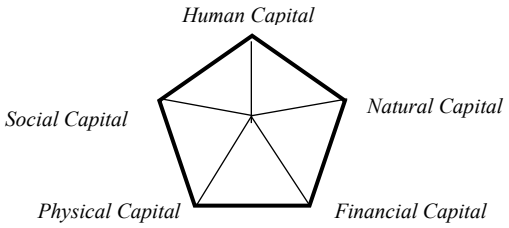

Figure 1. Diagram *Pentagonal Assets*. Source: ([DFID], 1999)

The Livelihood Vulnerability Index (LVI) is a tool for assessing a community's susceptibility to alterations in environmental, social, and economic factors (Hahn et al., 2009). This study used the LVI approach to assess the vulnerability level of agricultural households about the assets they possess and manage for their sustenance. The LVI approach comprises several primary components, including vulnerability indicators and subcomponents that serve as variables constituting the main components. This flowchart depicts the interrelationship among livelihood vulnerability, livelihood capital (SLA), and livelihood resilience. Robustness was operationalized as the capacity of farming households to absorb shocks without substantial loss of productive function, measured through indicators such as continuity of crop production, maintenance of income sources, and availability of physical and financial buffers during flood and pest disturbances. Stability referred to the ability to maintain relatively consistent livelihood outcomes over time, captured through yield variability, income fluctuations across seasons, and food availability under recurrent stress conditions. Flexibility denoted the adaptive capacity of households to adjust livelihood strategies in response to shocks, assessed through livelihood diversification, adoption of alternative farming practices, and engagement in non-farm income activities. This clearer delineation strengthens the internal validity of the resilience framework and facilitates comparison with related empirical studies.

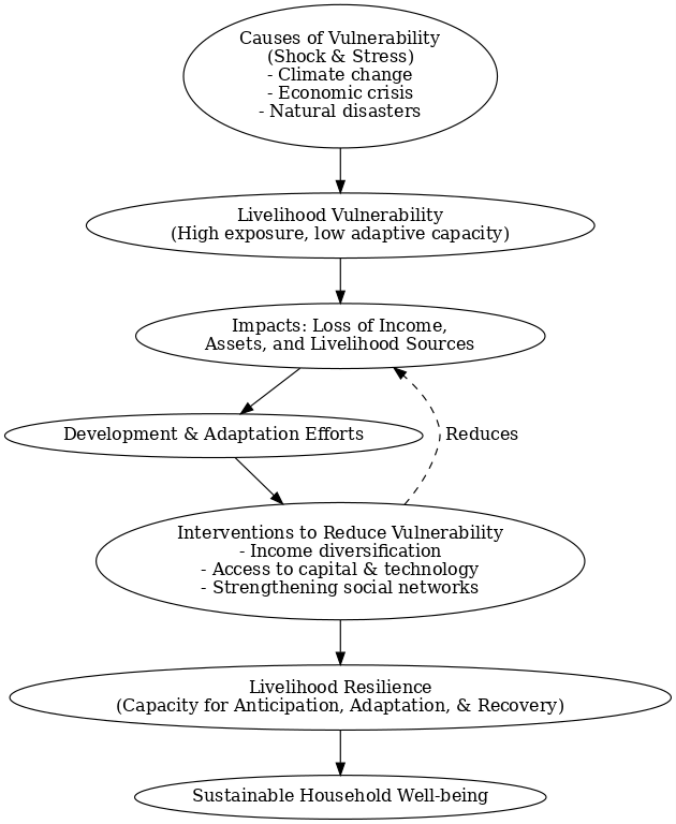

Figure 2. The relationship between the concepts of vulnerability and livelihood resilience

A population refers to the complete set of objects or subjects possessing specific qualities, as defined by the researcher for the purpose of study (Sugiyono, 2014). This study's unit of analysis is farming households. There are 132 farmer proprietors situated in the lowlands, whose rice fields are inundated owing to excessive rainfall and are impacted by rodent infestations. This study employs probability sampling via a basic random sample strategy. Simple random sampling is a sample technique executed randomly, disregarding the strata within the population. The study's environment is quite homogeneous. The Slovin formula is employed to calculate sampling, with the population diversity value derived from the variation among all samples utilized in this study.

$$n = \frac{N}{1+Ne^2} \quad (1)$$

Where:

n : Sample size.

N : Population size (the total number of farmer households working as farmers).

e : Tolerance due to imprecision caused by sampling errors that can be tolerated. In this study, N was found to be 120, and e was set at 10%. The following is the sample calculation using the above formula:

$$n = \frac{120}{(1+120(0,1)^2)} = \frac{120}{2,2} = 54,54 \approx 55 \text{ Respondents} \quad (2)$$

The value of e, or the permissible error rate, is 10%. The study utilized a sample size of 55 respondents from farming households with rice fields impacted by flooding and rat infestations. This study focused on farming households in Kutawaluya District, specifically those farmers impacted by flooding and rat infestations.

RESULTS AND DISCUSSION

The respondents' characteristics in this study included land area and ownership status. The land area serves as a criterion for responders in assessing their rice production and also affects the capital in their agricultural endeavors. A greater land area owned by farmers correlates with higher production yields, thereby enhancing their income. Land size remains a critical factor influencing agricultural productivity and household income among smallholder farmers. Larger cultivated land areas generally enable higher production levels, economies of scale, and greater income stability, thereby strengthening livelihood capacity. Recent empirical studies confirm that farm size is positively associated with productivity and welfare outcomes, particularly in rice-based farming systems where land availability determines access to natural capital and production intensity (Gollin, 2018; Place, 2009). In the context of Kutawaluya District, the predominance of medium-sized landholdings suggests moderate production potential; however, exposure to ecological risks such as floods and pest infestations constrains the ability of land size alone to secure stable livelihoods. Table 4 presents the facts regarding the area of land cultivated by rice paddy farmers.

Table 4. Characteristics of Respondents Based on Land Area

Land Area (ha)	Number of people	Persentase (%)
<0,5	12	21,82
0,6-2	31	56,36
Total	55	100,00

According to Table 4, Land ownership status refers to the condition of farmers about the agricultural land they manage and cultivate. The condition of land ownership will significantly influence farmers' decisions concerning their agricultural enterprises. Land ownership status significantly shapes farmers' decision-making autonomy, investment behavior, and willingness to adopt agricultural innovations. Recent studies demonstrate that secure land tenure enhances farmers' incentives to invest in productivity-enhancing technologies and long-term land management practices, while tenant and sharecropping arrangements often limit adaptive decision-making due to uncertainty and contractual constraints (Ghebru, 2021; Guèdègbé & Lokonon, 2025). In Kutawaluya District, the dominance of

owner-operated land reflects inherited tenure systems that provide a degree of stability; however, ownership alone does not guarantee resilience when ecological risks undermine production and income. This finding suggests that tenure security must be complemented by effective risk management and institutional support to enhance livelihood resilience. Table 4 presents the facts regarding the area of land cultivated by rice paddy farmers.

Table 5. Characteristics of Respondents Based on Landownership Status

Landownership Status	Number of people	Percentage (%)
Proprietor Farmers	38	69,09
Tenant Farmers	7	12,73
Total	55	100,00

According to Table 5, the land ownership status of rice paddy farmer respondents in Kutawaluya District predominantly consists of owned land, with 38 farmers representing 69.09%. This is followed by sharecroppers, comprising 10 farmers at 18.18%, and land renters, totaling 7 farmers at 12.73%. This phenomenon arises because the land cultivated by respondent farmers in Kutawaluya District has been inherited over generations, and the status of land ownership significantly impacts their decision-making in operating their agricultural enterprises.

Agricultural households in Kutawaluya District face heightened livelihood vulnerability due to the combined effects of recurrent flooding and rodent infestations. According to recent climate vulnerability frameworks, vulnerability arises from the interaction between exposure, sensitivity, and adaptive capacity under climate-related stressors (Intergovernmental Panel On Climate Change (IPCC), 2023) The high Ecological Livelihood Vulnerability Index (LVI) observed in this study reflects farmers' strong dependence on rice-based natural capital and limited capacity to buffer environmental shocks. Similar patterns have been documented in flood-prone agricultural regions in Indonesia and South Asia, where compound risks—rather than single hazards—significantly increase livelihood vulnerability among smallholder farmers (Ibrahim & Ali, 2023; Yang et al., 2021). These findings highlight the need to address ecological vulnerability through integrated risk management approaches.

This study, based on the research of Azzahra et al., (2017), assesses livelihood vulnerability through the Livelihood Vulnerability Index (LVI), which is categorized into three segments: Ecological LVI, Social LVI, and Economic LVI. The Ecological LVI reflects vulnerability concerning environmental factors and natural resources utilized by farming households. Social LVI denotes susceptibility for social interactions, networks, norms, and trust within social contexts, including family, neighbors, relatives, agricultural groups, extension agents, and local governance. Economic LVI denotes vulnerability in economic dimensions, particularly concerning the livelihoods of agricultural households. The LVI calculation comprises three elements: exposure, sensitivity, and adaptive capability. An LVI rating ranging from 0 to 0.35 signifies a minimal degree of livelihood risk. An LVI rating ranging from 0.36 to 0.65 signifies a moderate degree of livelihood risk. An LVI rating ranging from 0.66 to 1 signifies an elevated degree of vulnerability. The subsequent values of economic, social, and ecological LVI for agricultural households in Kutawaluya District are presented Figure 3.

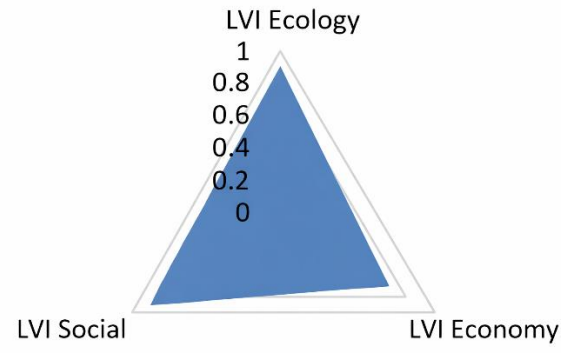

Figure 3. Livelihood Vulnerability Index (LVI) Social, Economy, and Ecology

The Ecological LVI exhibits the maximum value at 0.9, indicating significant vulnerability as it approaches 1. Agriculture, the primary source of income for farming people in Kutawaluya District, is

jeopardized by floods and rodent infestations, resulting in crop failure. This aligns with (Nadiyah et al., 2024) findings indicating that during the intense rainy season, rice fields become excessively moist, facilitating the proliferation of rat pests. The Social LVI value of 0.87 signifies that households in Kutawaluya District experience social vulnerability. This scenario pertains to the manner in which farmers address floods and rat infestations, wherein they continue to operate independently rather than collaboratively. Despite the organization of gropyokan events by extension workers, numerous farmers remain absent. The minimal Economic LVI value of 0.7 signifies that agricultural households retain money, assets, and access to credit in the case of crop failure. Farming households in precarious situations possess five livelihood capitals that serve as a buffer to attain resilience. The five forms of livelihood capital are natural capital, social capital, financial capital, physical capital, and human capital. This aligns with the findings of Ibrahim & Ali, (2023), which assert that households will undertake all feasible measures to secure the sustainability of their livelihoods, incorporating coping methods that leverage livelihood capital. The subsequent data represents the livelihood capital score of agricultural households in Kutawaluya District, Karawang Regency.

Table 4. Livelihood assets of farmer households in Kutawaluya District, Karawang

Livelihood Assets	Indicator (Azzahra, 2022)	Score
Human Capital	Problem-solving ability	1,727
	Ability to adapt to work	1,636
	Ease of access to jobs	1,418
	Time spent on knowledge improvement	1,854
	Work completion ability	1,618
Natural Capital	Ease of access to irrigation water	2
	Ease of adaption to natural circumstances	1,745
	Ease of access to natural resources	1,727
Physical Capital	Ownership of agricultural assets	1,945
	Ownership of non-agricultural assets	2
	Ownership of household assets	1,927
	Ease of asset use	1,781
	Ownership of assets that can be sold	1,181
Financial Capital	Income sufficiency	1,2
	Savings ownership	1,327
	Ease of Loan Access	1,890
	Debt ownership	1,2
	Ease of Access to Assistance	1,2
Social Capital	Ease for collecting information from groups	1,981
	Trust and solidarity with neighbours	1,963
	Participation and activity in organizations	1,454
	Trust extension workers	1,963
	Freedom and mutual respect	2

The measurement of livelihood assets was performed utilizing the Gutmann scale for each indicator question across all livelihood capitals. The measurement findings were averaged and categorized into intervals: 1.00 - 1.55 for low values, 1.55 - 2.55 for medium values, and 2.55 - 3.00 for high values. The table indicates that social capital possesses the highest livelihood capital, with an average score of 3.00. Despite high ecological vulnerability, farming households mobilize multiple livelihood assets to enhance resilience, consistent with the Sustainable Livelihoods Approach. Among the five forms of livelihood capital, social capital emerges as a key resilience mechanism, facilitating information exchange, collective action, and informal risk sharing. Recent studies emphasize that social networks, trust, and community cooperation significantly improve adaptive capacity and resilience in flood-affected rural areas (Aldrich & Meyer, 2015; Sulandjari & Azzahra, 2024). In Kutawaluya District, strong trust among neighbors and extension workers supports collective pest control efforts; however, limited participation in formal farmer organizations constrains the effectiveness of coordinated adaptation strategies. During a rat infestation, extension workers in Kutawaluya District convene a gropyokan (a community gathering), although numerous farmers are unable to participate. Management of flooding and rat infestations remains separate. This aligns with the research conducted (Sulandjari & Azzahra, 2024), which indicates that rural communities exhibiting a suburban culture shaped by industrialization and modernization may experience an enhancement in social capital when facing

vulnerabilities, such as those presented by the COVID-19 pandemic. Additionally, research findings (Ibrahim & Ali, 2023; Mariyani & Nisa, 2025) also mention that social capital is utilized by rainfed rice farmers in managing their resources to cope with the threat of food insecurity due to climate change. Enhanced social capital is beneficial as it provides a buffer for households in precarious situations; thus, it must be preserved by focusing on the components that constitute social capital. This is in line with information from Mr. S, the head of the farmers' group, who stated that,

> *"when there is a rat pest attack, farmers work together in a spirit of mutual cooperation to find a solution, because rat pests cannot be dealt with individually. These rats move around, and we don't want our own rice fields to be safe while the fields next to us, which also belong to our neighbors and relatives, are affected. Therefore, it must be done together, in a spirit of mutual cooperation (gotong royong)"*

The physical capital of agricultural households in Kutawaluya District carries significance. This aligns with the livelihood vulnerability index, indicating that farming households in Kutawaluya District own production assets, non-production assets, and household assets that can be liquidated during a crisis. The natural capital value of 2.89 suggests that farming households continue to significantly utilize natural resources within their living area. The human capital value of 2.33 suggests that the majority of agricultural households rely on a singular income source, rendering them especially susceptible when that income is jeopardized. Financial capital is the least valued livelihood capital, with a value of 2.02. This indicates that numerous agricultural households remain without savings. Furthermore, at the onset of the planting season, numerous farmers initially incur debt for agricultural capital, which has to be repaid at the time of harvest. Nevertheless, when pest infestations or floods transpire, rice production diminishes further, potentially leading to crop failure, which prevents farmers from repaying their debts and compels them to incur further loans for sustenance or agricultural investment in the subsequent planting season. The subsequent depiction is a pentagonal representation of agricultural household livelihoods in Kutawaluya District, Karawang Regency.

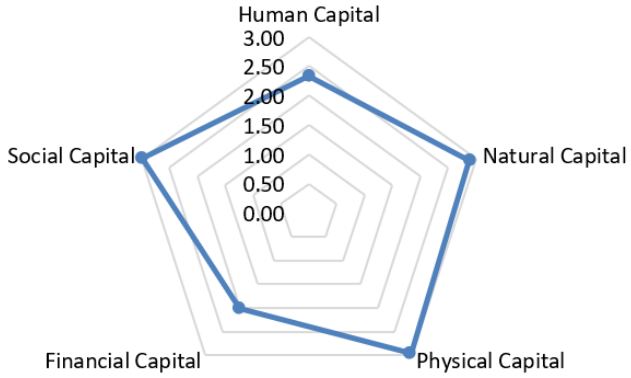

Figure 4. Pentagonal representation of agricultural household livelihoods in Kutawaluya District, Karawang Regency

Recent studies indicate that low financial capital exacerbates vulnerability by reducing households' capacity to absorb shocks and recover from crop failure, particularly in climate-exposed agricultural systems (Gebrehiwot & Veen, 2021). When floods and pest infestations lead to yield losses, farmers are often unable to repay loans, reinforcing cycles of indebtedness and livelihood insecurity. Similar debt-driven vulnerability has been reported among rice farmers in Southeast Asia, underscoring the importance of accessible credit schemes and financial risk protection mechanisms for strengthening long-term resilience (Ibrahim & Ali, 2023). This aligns with information from Mr. M, one of the farmers who relies on capital or borrows from middlemen each planting season,

> *"Often the harvest is not much because of rat infestations and floods, so it's not enough for the next planting season. We're forced to borrow first so we can plant. Whether we like it or not, we also try to optimize production, but we still can't control it (pests and natural disasters)."*

This study categorizes resilience indicators into five distinct types: Toughness/Robustness of Livelihood, Rapidity of Recovery, Security of Livelihood System, Stability of Livelihood, and

Flexibility to Adapt to Change. The resilience of livelihood is determined by the quantity of alternative income sources, the susceptibility of these sources to disruptions, and the degree of utilization of livelihood assets. The Rapidity of Recovery encompasses the average duration required for agricultural households to repay debts, secure employment, recuperate from illness, regain stability following natural disasters, and obtain loans during financial exigencies. The security of the livelihood system encompasses the availability of economic guarantee institutions, the preparedness of farmer groups to confront crises, and the readiness of local governments to address crises. The stability of livelihood is determined by the quantity of permanent employment, the availability of supplementary jobs, and the skill level of the household head. Flexibility in adapting to change encompasses the extent of knowledge regarding ecosystem alterations, the understanding of the consequences of these changes, the variety of available adaptation strategies, the degree of technological preparedness to address changes, and the level of socio-cultural readiness to confront such changes (Sulandjari & Azzahra, 2024). This is a pentagonal examination of the livelihood resilience of farming households in Kutawaluya District, Karawang Regency.

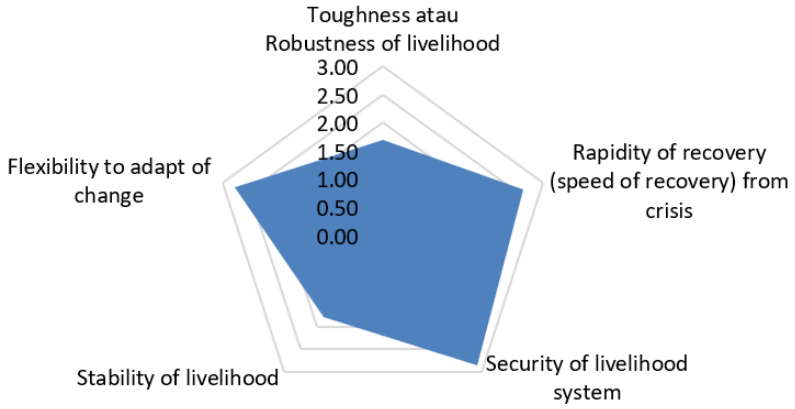

Figure 5. Pentagonal examination of the livelihood resilience of farming households in Kutawaluya District, Karawang Regency

Livelihood resilience was assessed using a Likert scale, weighted by the number of respondents, where a score of 1 indicated poor resilience, 2 indicated medium resilience, and 3 indicated strong resilience. The most significant resilience indicator was livelihood system security, scoring 2.85, followed by adaptability to change at 2.76, recovery speed at 2.64, livelihood stability at 1.78, and the least was livelihood robustness at 1.69. Farming households in Kutawaluya District have convenient access to information from field extension staff, enabling farmers to engage actively in farmer group activities. Trust levels are notably elevated among neighbors and family; nonetheless, there exists a deficiency of trust in governmental aid. The results indicate that livelihood vulnerability among farming households in Kutawaluya District is predominantly driven by ecological stressors, particularly recurrent flooding and rodent infestations. This high ecological vulnerability reflects not only exposure to environmental hazards but also the structural dependence of households on rice farming as their primary livelihood. Similar findings have been reported in flood-prone rice-growing regions in Indonesia and South Asia, where heavy reliance on natural capital significantly increases household sensitivity to climate-induced shocks (Ibrahim & Ali, 2023; Lusinga-Machikicho & Mutanana, 2022). The coexistence of floods and pest outbreaks in Kutawaluya suggests that compound risks, rather than single hazards, pose the greatest threat to smallholder livelihoods. Despite high ecological vulnerability, farming households demonstrate adaptive capacity through the mobilization of livelihood assets, particularly social capital. Strong trust-based relationships with neighbors, family members, and agricultural extension workers facilitate access to information, collective action, and informal risk sharing. This finding is consistent with recent international and regional studies showing that social networks and community cooperation are critical mechanisms of livelihood resilience in flood-affected agricultural systems (Mariyani & Nisa, 2025; Sulandjari & Azzahra, 2024). However, limited participation in formal farmer organizations indicates that social capital in Kutawaluya operates largely through informal mechanisms, which constrains its effectiveness for coordinated pest and flood management.

The prominence of livelihood system security as the strongest resilience indicator suggests that farmers prioritize livelihood persistence rather than transformation. Continuing rice cultivation despite repeated

crop losses reflects a “stay-and-adapt” strategy commonly observed among smallholder farmers with limited access to financial capital and alternative employment opportunities (Ibrahim & Ali, 2023). Weak financial capital, characterized by low savings and high dependence on seasonal debt, emerges as a key constraint to long-term resilience, as crop failure limits farmers’ ability to repay loans and perpetuates cycles of vulnerability. Similar debt-driven vulnerability dynamics have been documented among rice farmers in climate-exposed regions of Southeast Asia (Lusinga-Machikicho & Mutanana, 2022). From a theoretical perspective, this study advances livelihood resilience research by integrating the Livelihood Vulnerability Index (LVI) with the Sustainable Livelihoods Approach (SLA) within a single analytical framework. Unlike previous studies that examine floods or pest outbreaks separately, this integrated approach demonstrates how multidimensional vulnerability interacts with livelihood asset endowments to shape resilience outcomes. The findings reinforce recent arguments that resilience cannot be understood without jointly considering exposure, asset capacity, and adaptive responses (Ibrahim & Ali, 2023).

Practically, the findings highlight the need for interventions that move beyond traditional practices such as *gropyokan*. Farmers would benefit from integrated pest management, improved drainage systems, and flood-tolerant rice varieties. Extension agents play a crucial role in strengthening resilience by facilitating farmer group participation and disseminating adaptive knowledge. For policymakers, investments in flood control infrastructure, institutionalized pest management programs, and accessible credit schemes are essential to reduce ecological vulnerability and strengthen livelihood security in rice-producing areas. This study is limited by its site-specific focus and cross-sectional design, which restrict generalizability and temporal analysis. Future research should adopt longitudinal and comparative approaches across agroecological zones to better capture dynamic resilience pathways and institutional influences under compound environmental risks.

CONCLUSION

This study reveals that farming households in Kutawaluya District experience high livelihood vulnerability, predominantly driven by ecological factors. The Ecological Livelihood Vulnerability Index (LVI) records the highest score, reflecting farmers’ strong dependence on rice-based natural resources and their exposure to recurrent flooding and rodent infestations. These stressors significantly reduce agricultural output and threaten household income stability, confirming that ecological shocks remain the primary source of vulnerability for smallholder rice farmers in lowland areas. Despite these challenges, farming households demonstrate notable resilience supported by multiple livelihood assets. Among the five forms of livelihood capital, social capital plays a particularly important role in buffering ecological risks. Strong trust-based relationships among farmers, neighbors, and agricultural extension workers facilitate information exchange and collective action. The highest resilience score is observed in the security of the livelihood system, indicating that farmers prioritize sustaining rice farming despite persistent risks. However, existing mitigation practices, such as *gropyokan*, remain insufficient to fully control rodent populations, underscoring the need for more integrated and sustainable pest and flood management strategies. Theoretically, this study contributes to the sustainable livelihood and resilience literature by integrating the Livelihood Vulnerability Index (LVI) with the Sustainable Livelihoods Approach (SLA) within a single analytical framework. Unlike previous studies that examine floods or pest outbreaks separately or focus solely on vulnerability or adaptation, this research demonstrates how multidimensional vulnerability interacts with livelihood asset endowments to shape household resilience. The findings emphasize the compensatory role of social capital in contexts of high ecological vulnerability, thereby extending resilience theory in smallholder agricultural systems. Practically, the results suggest that farmers should strengthen collective action through coordinated pest management, adaptive cropping strategies, and the use of flood-tolerant rice varieties. Extension agents play a key role in enhancing resilience by improving access to timely information and supporting farmer learning and innovation. For policymakers, prioritizing investments in flood control infrastructure, drainage systems, and extension services is essential to reduce ecological vulnerability and strengthen livelihood security in rice-producing areas. This study is limited by its relatively small sample size and site-specific focus, which may constrain generalizability. Additionally, the cross-sectional design does not capture temporal dynamics of vulnerability and resilience. Future research should expand spatial coverage, employ longitudinal approaches, and incorporate institutional and policy dimensions to deepen understanding of livelihood resilience under multiple environmental stressors.

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CRediT Contribution. FA conceived and designed the study; SM collected and analyzed the data; AM and RM contributed to data interpretation and literature review; IKMM and HN drafted the manuscript; all authors reviewed and approved the final version of the manuscript.

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