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The Livelihoods Vulnerability of Farmers in Upstream and Downstream Areas in Facing Natural Disasters in South Kalimantan, Indonesia

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Abstract

This study applied the Livelihood Vulnerability Index to developing countries' agricultural and natural resource-dependent communities. The index is involved in a comparative analysis of the vulnerability of upstream and downstream communities in Banjar District, which is expected to bear some of the most severe impacts of climate change in South Kalimantan. The major components indices of the Livelihood Vulnerability Index (LVI), such as Socio-demographic profile, Livelihood strategies, Social network, Health, Food, Water, Natural disaster, and climate variability, were calculated based on survey data. The calculated results showed that those farmer households in the downstream areas feel greater exposure (exposure) and sensitivity due to climate variability (floods). Meanwhile, farmer households in the upstream area are more vulnerable in capacity. In addition to identifying susceptible persons and locations, the study gives appropriate knowledge, information, and practical recommendations to support adaptation decisions as predicted by the vulnerability.

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Introduction

Climate change harms agricultural production, putting numerous world regions on the verge of catastrophe. (Araro, Legesse and Meshesha, 2020). Increased occurrence and frequency of natural disasters, such as droughts and floods, are the most deadly dangers of global change (Sertse *et al.*, 2021).The greater reliance of the population on the agricultural sector has made it increasingly difficult as a sustainable source of income today. Agriculture will be even more vulnerable due to alterations in climate variables in the future. (IPCC Working Group II, 2022).

These difficulties are particularly concerning for a developing country like Indonesia, where agriculture contributes a significant portion of Gross Domestic Product (GDP) and employs more than 29% of the labor force Badan Pusat Statistik Indonesia, 2020; van de Vuurst and Escobar, 2020).

Variations in crop yield caused by frequent variations in environmental factors will be a significant consequence of climate change (Matano, 2018). Furthermore, extreme climatic events, soil salinity in coastal areas, and the incidence of pests and illnesses owing to increased temperature and humidity may have additional adverse effects on the agriculture sector (Jakariya *et al.*, 2020). Despite technological advances, climatic conditions remain the primary determinants of agricultural productivity (Firdaus *et al.*, 2020). Addressing the concerns to develop solutions to minimize agricultural vulnerability would necessitate an integrated and comprehensive management plan focusing on hazard vulnerability and the climate change resilience of the coastal population. (Bedeke *et al.*, 2019; Sajjad and Chan, 2019).

Various adaptation methods have been documented as coping skills to respond to climatic shocks that impact agriculture. (Gravitiani *et al.*, 2018; Mekonen and Berlie, 2021; Quiroga *et al.*, 2020). These strategies include efforts to adapt farming and livelihoods to climate change risks on and off the farm and measures to mitigate the effects of climate change on farming and livelihoods. (Gravitiani, Fitriana and Suryanto, 2018; Parker *et al.*, 2019; Tessema and Simane, 2019). On-farm adaptation techniques are primarily concerned with modifying farming systems through different crop types, adopting better soil and water management practices, intercropping and shuffling crop sowing patterns, and timing crop harvesting. (Esham and Garforth, 2013; Kumar and Sidana, 2017; Poudel, Joshi and Pokhrel, 2018).

According to the literature, perception and adaptation to climate risk at the farm level are primarily influenced by various social and economic factors linked with farm households (Wanigasundera and Alahakoon, 2014; Herath, Hasanov and Park, 2020). Furthermore, it depends on local institutions' technology and knowledge-based interventions, which can help farmers adapt to and perceive climate change more effectively (Suantapura, 2016) and on their efforts. According to studies, farmers' socioeconomic characteristics such as income and educational level (Dhanya *et al.*, 2021; Kumar & Sidana, 2017), their farm assets such as livestock and farm size, and, perhaps most importantly, their access to critical institutional services such as financial and advisory services are reported to be the essential determinants of farm-level adaptation. (Herath and Thirumarpan, 2017; Esfandiari *et al.*, 2020; Kim *et al.*, 2021). Indonesia is located at the junction of four major plates: Eurasia, Indo-Australia, Philippines, and Pacific. The tropics and confluence of two oceans and continents render Indonesia prone to floods, landslides, flash floods, extreme weather, waves and abrasion, and dryness, which can cause forest and land fires (UNFCCC, 2020). Throughout 2021, Indonesia recorded 3,115 natural disasters.

The dominating disaster events are floods (1,310 events), twisters (814 events), and land landslides (633 events). The impact of natural disasters in 2021 is more than 8.6 million people suffering and displaced, and 676 people died. Then, the amount of disaster infrastructure between more than 142 thousand houses and three thousand seven hundred are educational facilities, health, offices, roads, and bridges. Besides disasters caused by natural phenomena, Indonesia is also trying to control The spread of Covid-19, designated as a Non- natural National Disaster with an impact of more than 100 (BNPB, 2022).

Vulnerability Indicators help monitor and keep track of the changing vulnerability over time and space (Gahatraj, Jha and Singh, 2018; Asfaw *et al.*, 2021).

The three components that characterize vulnerability include exposure, sensitivity, and adaptive capacity (Nor Diana *et al.*, 2019). Local economic, social, and political factors can also significantly affect vulnerability components at the household level (Apriyana *et al.*, 2017). Climate change is a widely-discussed topic and requires resources on a global scale. Still, for this paper, the authors focused on finding adaptation strategies to cope with vulnerabilities related to rice production that would be specific for each region and could be managed locally. As a country with its unique geographical location, Indonesia is prone to natural disasters and climatic effects. Therefore, it becomes next to impossible to maintain proper resource management when mobility needs to be limited during such disasters, be it in the geographical or health sector.

The selection of indicators in this study considers both local and indigenous knowledge. Regional views and experiences of climatic variability at the community level can assist in identifying the variables that enable or restrict the ability of communities to respond to, recover from, and adapt to climate change at the local level. The strategy incorporates local and traditional knowledge to facilitate more effective decision-making, planning, and management in farm areas sensitive to climate change concerns (Nor Diana *et al.*, 2019).

The study finishes with a presentation and evaluation of the LVI, which is based on actual findings and local needs and can be used to influence local climate adaptation and mitigation efforts.

Materials and methods

Description of the study area

Banjar Regency is located in South Kalimantan Province and has a land area of 38,744.22 km² with 572,109 people, most of whom work in the agricultural sector (BPS, 2022). There have been 6 (six) disasters in the last five years. Floods, forest and land fires, and hurricanes are the most common.

The altitude of Banjar Regency is about 0-1,878 meters. The low position of this regency has caused a lack of water flow on the ground. The river cannot handle the air movement during the rainy season, causing it to overflow into residential neighborhoods. Banjar Regency has a risk level of 165.12, rated high by the Disaster Risk Index (BNPB, 2022).

Sampling and data collection

Respondents from the study area were selected through a multi-stage sampling technique. Initially, the Banjar district was purposively established in the South of Kalimantan, given its high vulnerability to climate change. In the second stage, two sub-districts were deliberately chosen to represent areas very prone to flooding in the upstream and downstream regions of the district.

In the third stage, the sample size for each village was calculated considering its total number of households using Yamane's formula (Yamane, 1967). At the fourth and last stage, the estimated sample size of each village (ranging from 25 to 35) was randomly selected from the respective sub-districts using a household list acquired from the district-level agricultural department, making a total sample of 395 households.

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

Where; n denotes the sample size, N designates the total number of households, and e designates the margin of error (5%).

Farmers' responses were collected using a pre-tested questionnaire, and Pretesting was done using a sufficient number of non-sample respondents through a pilot study. Based on the nature and extent of responses obtained, necessary modifications were made to the questionnaire to ensure clarity and completeness in generating the needed information. The main parts of the questionnaire included households' socioeconomic and farm-related attributes, perception of climate change and associated risks, adaptation strategies to climate change, and effectiveness of adopted plans.

In addition to primary data, secondary data were collected through reviewing materials from relevant public institutions to corroborate the study's conclusions.

Calculating LVI: Composite Index Approach (SLVI)

The Livelihood Vulnerability Index (LVI) is an analytical tool for the vulnerability of farming households. LVI calculation uses the method developed by Hahn *et al.* (2009). The LVI approach is carried out by determining the main and sub-components. The main components are socio-demographic, livelihoods, health, social networks, food, water, natural disasters, and climate variability. Meanwhile, LVI, according to the IPCC (LVI-IPCC), states vulnerability to exposure (exposure), risk (sensitivity), and adaptive capacity (adaptive capacity).

LVI estimation used the formula from the Human Development Index, which used ratio data determined by the minimum and maximum values chosen by the respondents. By using this measurement, respondents who are the object of research can openly provide an assessment of something.(Sullivan, Meigh and Fediw, 2002) LVI measurement indicators can be seen in Table 1.

The LVI formula is easy to understand because it gives all essential features the same weight. The LVI uses a balance-weighted average method (Sullivan *et al.*, 2002), in which each sub-component contributes the same amount to the overall index, even though each principal component has a different number of sub-components. This weighting scheme could be adjusted by future users as needed.

Since each subcomponent is measured on a different scale, each must be made into a standard index first. The equation used for this conversion was adapted from the one used in the human development index to figure out the life expectancy index, which is the ratio of the difference between the actual life expectancy and a pre-selected minimum and range of pre-determined maximum life expectancies. (UNDP, 2019):

$$Indeks_{sd} \frac{s - s_{min}}{s_{max} - s_{min}} \quad \text{.......(1)}$$

Where S_d is the original sub-component for sub-district d, S_{min} and S_{max} are the minimum and maximum values. Sub-components such as the 'average agricultural livelihood diversity index' were created because an increase in the crud indicator, in this case, the number of livelihood activities undertaken by a household, was assumed to decrease vulnerability.

Following this logic and equation (1), the maximum and minimum values were modified to normalize these subcomponents. After each was standardized, the sub-components were averaged using Eq. (2) to calculate the value of each major component:

$$M_d = \frac{\sum_{i=1}^{n} index\, s_{d}i}{n} \quad \text{.......(2)}$$

Where M_d is one of the seven major components for district d (Socio-Demographic Profile, Livelihood Strategies, Social Network, health, Food, Water, or Natural disasters and Climate Variability), index s_di represents the sub-components, indexed by i that make up each major component, and n is the number of sub-components.

Once values for each of the seven major components for a district were calculated, they were averaged using Eq. (3) to obtain the district-level LVI:

$$LVI_d = \frac{\sum_{i=1}^{7} w_{Mi} M_{di}}{\sum_{i=1}^{7} w_{Mi}} \quad \text{.......(3)}$$

LVId is the Livelihood Vulnerability Index for district d, which equals the weighted average of the seven major components. The weights of each significant element, w_{Mi} are based on the number of subcomponents that make up each major component. They are included to ensure that all subcomponents contribute the same amount to the overall LVI (Sullivan *et al*., 2002). This study's LVI is scaled from 0 (least vulnerable) to 0.5 (most vulnerable).

Calculating the LVI: IPCC Framework Approach (LVI-IPCC)

The alternate technique for calculating LVI includes the IPCC's definition of vulnerability by grouping the seven critical components under exposure, adaptive capacity, and sensitivity. Each major part comprised several subcomponents or indicators, the same as in the LVI.

In this approach, an alternative method for calculating the LVI is developed that incorporates the IPCC vulnerability definition. Measuring sensitivity involves evaluating the existing food and water security and health situation. Table 2 shows seven significant components in the LVI (IPCC) framework. Exposure of the study population is measured by the number of natural disasters that occurred in the past six years, while climate variability is measured by the average standard deviation of the maximum and minimum monthly precipitation over six years.

The demographic profile of a district quantifies adaptive capacity (e.g., percentage of female-headed households), the type of livelihood strategies employed (e.g., predominately agricultural or also collect natural resources to sell in the market), and the strength of social networks (e.g., percent of residents assisting neighbors). The same subcomponents are outlined in Table 1 as well as Eqs. (1)–(3) were used to calculate the LVI–IPCC. When the significant components are combined, the LVI–IPCC diverges from the LVI. Rather than merge the essential parts into the LVI in one step, they are first combined according to the categorization scheme in Table 2. The LVI-IPCC diverges from the SLVI when the significant components are combined. They are first connected by the equation (4) as given below:

$$CF_d = \frac{\sum_{i=1}^{n} W_{Mi} M_{di}}{\sum_{i=1}^{n} W_{Mi}} \quad \ldots\ldots (4)$$

Where CF_d is an IPCC-defined contributing factor (exposure, sensitivity, or adaptive capacity) for district d, Mdi is the significant component for district d indexed by i, w_{Mi} is the weight of each major part, and n is the number of essential features in each contributing factor. Once exposure, sensitivity, and adaptive capacity were calculated, the three contributing factors were combined using the following equation:

$$LVI_d - IPCC_d = (e_d - a_d).\, S_d \quad \ldots\ldots (5)$$

LVI ($IPCC_d$) is the LVI for district d, which is expressed using the IPCC vulnerability framework, "e_d" is the calculated exposure score, "a_d" is the calculated adaptive capacity score and "s_d" is the computed sensitivity score for district d. Here the scales of LVI-IPCC vary from -1 (least vulnerable) to 1 (most vulnerable).

Results and discussion

Livelihood vulnerability index

This session presents and discusses the vulnerability index computed from the survey findings. Comparing two sub-districts (Pengaron sub-district for the upstream area and Martapura Barat sub-district for the downstream area), including the subcomponents of the Livelihood Vulnerability Index, based on socio-demographic profiles, livelihood strategies, social networks, health, food, water, natural disasters, and climate variability revealed the principal contributing factors, such as socio-demographic profiles, livelihood strategies, social networks, health, food, water, natural disasters, and climate variability (LVI).

The Vulnerability of Rice Farmers' Household Livelihoods starts with looking at the values of the Exposure Index, the Adaptive Capacity Index, and the Sensitivity Index for each sub-districts.

Table 1. Major components and sub-components comprising the Livelihood Vulnerability Index (LVI).

Major component	Sub-component	Units	Source/adapted from
Socio-demographic profile	Dependency ratio	Ratio	(Hahn, Riederer and Foster, 2009)
	Percentage of non-educated household heads	Percentage	(Hahn, Riederer and Foster, 2009)
	The average age of the head of a family	Average	(Hahn *et al.*, 2009); (Cutter, Boruff and Shirley, 2003)
	Female-headed household percentage.	Percentage	(Hahn *et al.*, 2009); (Dolan and Walker, 2006)
	Proportion of illiterates	Percentage	(Hahn, Riederer and Foster, 2009)
Livelihoodstrategies	the percentage of households that work in each community	Percentage	(Hahn, Riederer and Foster, 2009)
	Percentage of households whose sole source of income is agriculture	Percentage	(World Bank, 1997)
	Index of Natural resources and livestock	1/ # resource	(Hahn, Riederer and Foster, 2009)
	Agricultural Livelihood Diversification Index Average (range: 0.20-1)a	1/ # livelihoods	(Hahn, Riederer and Foster, 2009)
Health	Average distance to a medical facility (minutes)	Minutes	(DHS), 2006)
	Percentage of households where afamily member had to miss work or school in the last two weeks due to illness	Percentage	(Hahn *et al.*, 2009); (Cutter, Boruff and Shirley, 2003)
	Percentage of households with a chronically ill family member	Percentage	(Hahn, Riederer and Foster, 2009)
	Access to the sanitation facility	Percentage	(Williamsburg Emergency Management, 2004)
Social networks	Average Borrow: Lend Moneyratio (range: 0.5–2)	Ratio	(Hahn, Riederer and Foster, 2009)
	Average Receive: Give ratio	Ratio	(World Bank, 1997)
	Affordability of amenities	1/ # amenities	(Williamsburg Emergency Management, 2004)
	Percentage of households that have not gone to their local government for assistance inthe past 12 months	Percentage	(Hahn, Riederer and Foster, 2009)
Food	The percentage of households whose only source of food comes from their family farm	Percentage	(Mehzabin and Mondal, 2021)
	Average Crop Diversity Index (range: >0–1)[a]	1/ # crops	(Hahn, Riederer and Foster, 2009)
	The average number of months out of a possible 12 in which a household has trouble locating food.	Months	(Hahn, Riederer and Foster, 2009)
	Percentage of households that do not store their crops	Percentage	(Mehzabin and Mondal, 2021)
	Percentage of households that do not save seeds	Percentage	(Mehzabin and Mondal, 2021)
Water	Percentage of homes that get their water from a natural source	Percentage	(Hahn *et al.*, 2009); (DHS (Demographic Health Survey), 2006)
	the time it takes to fetch drinking water from home	Minutes	(DHS (Demographic Health Survey), 2006)
	The inverse of the average amount of water a household store (range: 0–1)	1/ # liters	(Hahn, Riederer and Foster, 2009)
	Percentage of homes that don't have a steady supply of water	Percentage	(Hahn, Riederer and Foster, 2009)
Natural disasters and climate variability	Flood, drought, and storm events in the past six years	Count	(Williamsburg Emergency Management, 2004)
	Number of homes where someone was hurt or died because of the worst natural disaster in the last six years	Percentage	(Hahn, Riederer and Foster, 2009)
	Percentage of households that did not receive a warning about the pending natural disasters	Percentage	(Williamsburg Emergency Management, 2004)
	The monthly mean, a standard deviation of the daily minimum temperature	Celsius	(Instituto Nacionalde Estatistica, 2007)
	The monthly mean, a standard deviation of the daily maximum temperature	Celsius	(Instituto Nacionalde Estatistica, 2007)
	The monthly mean, a standard deviation of minimum daily temperature	Millimeters	(Instituto Nacionalde Estatistica, 2007)

Exposure Index

IPCC (2007) defines exposure as the extent to which climate change intersects the system. The system here can be interpreted as the pattern of life and Livelihood of the community and ecosystem. The calculation of the Exposure Index aims to find out more about the impact of climate change experienced by farming households. This method can be measured by finding the index value of the determinants of exposure, namely natural disasters and climate variability, and what is caused by these natural disasters and climate variability in farmer households. The calculation of the Exposure Index felt by farming households is presented in Table 3.

Table 2. Categorization of major components into contributing factors from the IPCC (Intergovernmental Panel on Climate Change) vulnerability definition for calculation of the LVI–IPCC.

IPCC contributing factors to vulnerability	Major components
Exposure	• Natural disasters and climate variability
Adaptive capacity	• Socio-demographic profile • Livelihood strategies • Social networks
Sensitivity	• Health • Food • Water

Rice farmer households in Pengaron Sub-districts have an exposure index of 0.273 which is lower than that of RTP in Martapura Barat Sub-districts, which is 0.391 (Table 3). Farmers in Pengaron Sub-district feel the impact of climate variability more significantly because most farmers rely on rainfed and only harvest once a year. After all, irrigation does not reach the rice fields.

Table 3. Exposure index values in both sub-districts as the impact of climate variability.

Component Main (Indicator)	Sub Component	Value is standardized		Main Component Value	
		Pengaron Sub-districts	Martapura Barat Sub-districts	Pengaron Sub-districts	Martapura Barat Sub-districts
Natural disasters andclimate variability	Flood, drought, and storm events in the past six years	0.54	0.89	0.273	0.391
	Number of homes where someone was hurt or died because of the worst natural disaster in the last six years	0.06	0.08		
	Percentage of households that did not receive a warning about the pending natural disasters	0.14	0.02		
	The monthly mean, a standard deviation of the daily minimum temperature	0.09	0.41		
	The monthly mean, a standard deviation of the daily maximum temperature	0.36	0.50		
	The monthly mean, a standard deviation of minimum daily temperature	0.44	0.44		

Some farmer households in Martapura Barat Sub-districts can harvest up to two times, especially for rice fields close to irrigation. This climate variability causes losses to the household economy of farmers due to the decline in the quality and quantity of rice production.

Table 4. Adaptive capacity index values in the two sub-districts as the impact of climate variability.

Component Main (Indicator)	Sub Component	Value is standardized		Main Component Value	
		Pengaron Sub-districts	Martapura Barat Sub-districts	Pengaron Sub-districts	Martapura Barat Sub-districts
Socio-demographic profile	Dependency ratio	0.31	0.37	0.261	0.293
	Percentage of non-educated household heads	0.25	0.32		
	The average age of the head of a family	0.30	0.32		
	Female-headed household percentage.	0.06	0.03		
	Proportion of illiterates	0.39	0.42		
Social network	Average Borrow: Lend Money ratio (range: 0.5–2)	0.31	0.39	0.235	0.367
	Average Receive: Give ratio	0.21	0.19		
	Affordability of amenities	0.20	0.24		
	Percentage of households that have not gone to their local government for assistance inthe past 12 months	0.75	0.64		
Livelihood strategies	the percentage of households that work in each community	0.22	0.10	0.367	0.356
	Percentage of households whose sole source of income is agriculture	0.35	0.42		
	Index of Natural resources and livestock	0.19	0.18		
	Agricultural Livelihood Diversification Index Average (range: 0.20-1)a	0.71	0.72		

Adaptive capacity index

Adaptive capacity describes an entity's ability to manage adverse impacts and take advantage of any opportunities that arise (IPCC, 2001). The Adaptive Capacity Index is needed to determine how farmer households make efforts to deal with climate change. Table 6 presents data on the adaptive capacity of farmer households in coping with climate variability.

The calculation of the adaptive capacity index results shows that farmer households in Martapura Barat Sub-districts are more vulnerable to adaptive capacity, which is indicated by an index value of 0.335 (Table 4). The driver of vulnerability to the adaptive capacity of farmer households in Martapura Barat Sub-districts is the main component of social networks, farmer households in Martapura Barat Sub-districts have a vulnerability of 0.367 is higher than that of Pengaron Sub-districts of 0.235.

This vulnerability is caused by the high percentage of dependence on government assistance, reliance on money loans to other parties, and the inactivity of respondents in farmer groups.

Adaptive capacity describes the ability of farmer households to manage the impact of climate variability, namely drought. The high adaptive capacity of farmer households will be able to reduce the level of vulnerability of farmer households.

Table 5. The value of the sensitivity index in the two sub-districts as the impact of climate variability.

Component Main (Indicator)	Sub Component	Value is standardized		Main Component Value	
		Pengaron Sub-districts	Martapura Barat Sub-districts	Pengaron Sub-districts	Martapura Barat Sub-districts
Health	Average distance to a medical facility (minutes)	0.56	0.43	0.366	0.366
	Percentage of households where afamily member had to miss work or school in the last two weeks due to illness	0.02	0.01		
	Percentage of households with a chronically ill family member	0.10	0.12		
	Access to the sanitation facility	0.26	0.22		
Food	The percentage of households whose only source of food comes from their family farm	0.27	0.10	0.592	0.592
	Average Crop Diversity Index (range: >0–1)[a]	0.51	0.76		
	The average number of months out of a possible 12 in which a household has trouble locating food.	0.36	0.13		
	Percentage of households that do not store their crops	0.94	0.96		
	Percentage of households that do not save seeds	0.88	0.96		
Water	Percentage of homes that get their water from a natural source	0.75	0.82	0.339	0.339
	the time it takes to fetch drinking water from home	0.37	0.62		
	The inverse of the average amount of water a household store (range: 0–1)	0.10	0.02		
	Percentage of homes that don't have a steady supply of water	0.13	0.15		

Sensitivity index

Sensitivity is the system's changing response, either positively or negatively. The sensitivity of farmer households is calculated through food, water, and land. The calculation of the sensitivity index of farmer households to climate variability is presented in Table 5.

In the main component of food, farmer households in the two sub-districts have almost the same sensitivity index, and although farm households in Pengaron Sub-districts are slightly more vulnerable, this is indicated by the index value of 0.444 for Pengaron Sub-districts and 0.408 for Martapura Barat Sub-districts. This sensitivity is due to farmer households in the two sub-districts relying more on food sources and other necessities of life from farming production (growing rice). If there is a decrease in the quantity and quality of rice production due to climate variability, it will affect the availability of food and fulfill the living needs of farmer households in both sub-districts.

Rice farmer household livelihood vulnerability due to climate variability

Calculating vulnerabilities with the composite index approach

The *Livelihoods Vulnerability Index* (LVI) method is an analytical tool to calculate the vulnerability of farmer households. LVI calculation uses the method developed by Hahn *et al.* (2009). The LVI approach is carried out by determining the main and sub-components. The main components are natural disasters and climate variability, socio-demographic, livelihood strategies (livelihoods); health social networks; food, and water. The vulnerability index or value of each principal component is presented in Table 6. Based on this value, it can be seen which sub-districts are more vulnerable due to climate variability.

Table 6. LVI value, vulnerability index of farmer households in both sub-districts.

Principal Components (Indicators)	Pengaron Sub-districts	Martapura Barat Sub-districts
Natural Disasters and Climate Variability	0.273	0.391
Socio-Demography	0.261	0.293
Livelihood Strategy	0.367	0.356
Social network	0.235	0.367
Food	0.366	0.195
Water	0.592	0.581
Land	0.339	0.404
LVI	-0.006	0.023

The LVI value of farming households in Martapura Barat Sub-districts is more vulnerable than those in Pengaron Sub-districts. Farmer households in Martapura Baratn Sub-districts are more susceptible to natural disasters, climate variability, socio-demographics, social networks, and land and natural disasters. In contrast, farmer households in Pengaron Sub-districts are more vulnerable regarding livelihood strategies, food, and water.

Table 7. LVI-IPCC values of farmer households in both sub-districts.

Parameter	Principal Components (Indicators)	Pengaron Sub-districts	Martapura Barat Sub-districts
Exposure	Natural disasters and variability	0.286	0.335
	Socio-demographic		
Adaptive Capacity	Livelihood strategy	0.444	0.408
	Social network		
Sensitivity	Health	0.273	0.391
	Food		
	Water		
LVI-IPPC		-0.006	0.023

Calculating vulnerabilities with the IPCC framework approach

LVI-IPCC value represents a vulnerability caused by exposure, sensitivity, and adaptive capacity. The calculation of the LVI-IPCC method conforms to the formulation of the Intergovernmental Panel on Climate Change (IPCC). The value of each parameter in the LVI-IPCC is presented in Table 7.

The combination of LVI-IPCC parameters, exposure, adaptive capacity, and sensitivity is presented in Fig. 1. Based on the analysis in Table 7, it can be seen that those farmer households in Martapura Barat Sub-districts (downstream area) feel greater exposure (exposure) and sensitivity due to climate variability (floods) compared to farmer households in Pengaron Sub-districts.

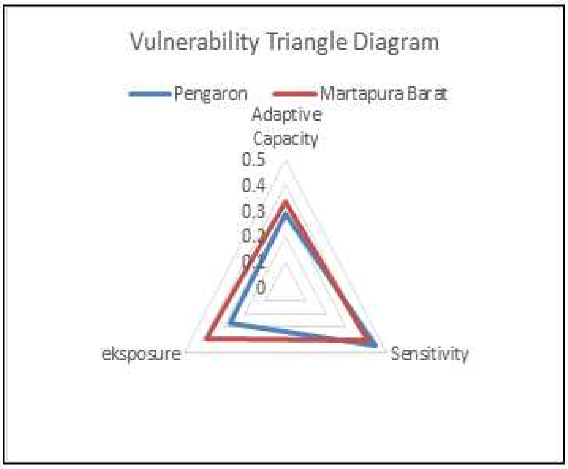

Fig. 1. LVI-IPCC vulnerability triangle in both sub-districtso.

Meanwhile, farmer households in Pengaron Sub-districts (upstream area) are more vulnerable in capacity. Based on Fig. 1, it can be seen that areas with a larger triangular area will also have a greater livelihood vulnerability. The smaller the LVI index value, the smaller the level of vulnerability or extreme importance. If it is -1, it is called least vulnerable; when it is +1, it is most vulnerable.

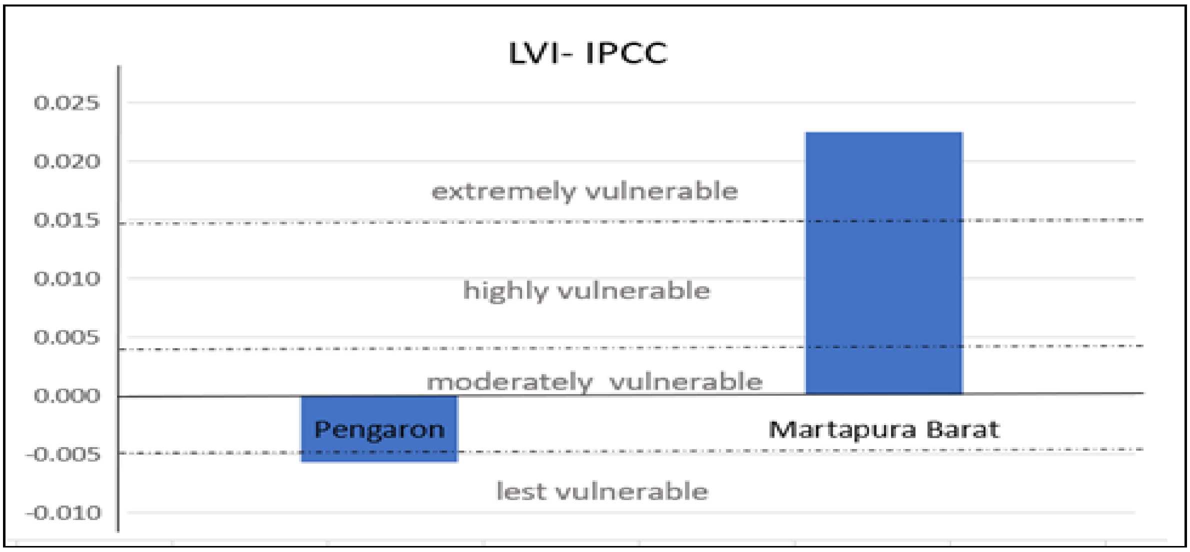

Fig. 2. Level of vulnerability in two sub-districts.

The value of LVI-IPCC varies from -0.0161 to +0.268. If this scale is subdivided into four equal ranges and named as less vulnerable (-0.0161< LVI-IPCC < -0.0054), moderately vulnerable (-0.0054< LVI-IPCC < 0.0054), highly vulnerable (0.0054 < LVI-IPCC < 0.0161) and extremely vulnerable (0.0161< LVI-IPCC < 0.0268). Then it is found from Figure 2 that the Pengaron sub-district (upstream area) is in the range of moderately vulnerable areas, while The Martapuran Barat sub-district (downstream area) is in the range of extremely vulnerable areas. Overall, farmer households in Martapura Barat Sub-districts have a higher livelihood vulnerability than those in Pengaron Sub-districts. This result is indicated by the LVI-IPCC value of 0.023 for farmer households in Martapura Barat Sub-districts, which is greater than the LVI-IPCC value of -0.006 for farmer households in Pengaron Sub-districts.

Conclusion

Based on the LVI value, farmer households in the downstream area are more susceptible to climate variability than farm households in the upstream. The response of farmer households to survive by carrying out livelihood adaptation mechanisms. Farming households in downstream areas diversify their work by becoming laborers and working in the service sector. In addition, farmers also sell their previous harvests. Meanwhile, farming households in the upstream areas are more likely to diversify their farms and utilize social networks. By implementing adaptation strategies, farm households can build livelihood resilience that can counteract the adverse effects of environmental change or climate variability.

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