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Perceived Capacity to Maintain Food Access under Extractive Pressure: Evidence from Rice-Farming Households in Bangka, Indonesia

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ABSTRACT

Purpose – This study examines the associations of perceived mining impacts, perceived climate variability, perceived market access, and adaptation strategies with households' Perceived Capacity to Maintain Food Access (PCMFA) among rice-farming households in Bangka and South Bangka Regencies, Indonesia, using the Sustainable Livelihood Framework (SLF).
Design/methodology/approach – A structured survey was conducted among 107 lowland rice-farming households. Data were analysed using Ordinary Least Squares regression with White heteroskedasticity-consistent robust standard errors.
Findings/Results – Perceived mining impacts were negatively and significantly associated with PCMFA. Perceived market access and adaptation strategies were positively and significantly associated with PCMFA, with market access showing the strongest positive standardised association. Perceived climate variability did not show a statistically significant direct association with PCMFA at the 5% level. The findings indicate that PCMFA is associated with both mining-related vulnerability pressures and livelihood capacities.
Originality/Value – This study applies the SLF in an extractive rural setting by distinguishing mining impacts and climate variability as vulnerability pressures from market access and adaptation strategies as livelihood capacities. It shows that mining-related pressure remains negatively associated with households' perceived capacity to maintain food access, while market access and adaptation strategies are associated with higher PCMFA. The findings support integrated environmental protection, market access, and livelihood-strengthening interventions in mining-affected agricultural areas.

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1. Introduction

A combination of simultaneous environmental, economic, and social factors is challenging the resilience of rural livelihood systems. In many developing nations, agricultural households are affected not only by climate uncertainty and market volatility, but also by the changes in the rural economic structure associated with the growth of the extractive sector. In this sense, the ability of a household to maintain access to food is an important indicator of its capacity to absorb a range of external shocks. Access to food is influenced not only by the physical availability of food, but also by the capacity of a household to preserve its livelihoods, manage risks, and adjust economically to environmental change. The ability of rural households to cope with growing pressures on food availability is an important issue on the agenda of sustainable rural development (Ellis, 1999; FAO et al., 2024; Scoones, 1998).

One type of pressure that has been receiving growing attention in the rural development literature is the presence of extractive industries. Mining activities are known to generate economic opportunities in terms of higher income and employment. At the same time, they can alter the structure of community livelihoods, decrease access to productive resources, and raise environmental vulnerability for households that depend on the agricultural sector (Dietz, 2023; Hilson & Garforth, 2013; Luning, 2014). Several studies have revealed that the linkage between mining and rural livelihoods is not necessarily wholly negative or positive. Rather, extractive activities frequently initiate complicated processes of livelihood transformation in which households must continually modify their economic strategies to support their well-being and long-term livelihood sustainability (Mkodzongi & Spiegel, 2019; Ofosu et al., 2020). In this setting, a household's capacity to maintain access to food can be viewed as a component of its livelihood resilience, allowing it to weather the economic and environmental shifts brought about by extractive operations.

These circumstances are especially pertinent to the Indonesian region of Bangka, which has long been recognised as one of the world's leading tin-producing locations. The tin mining industry has long been an important source of livelihood for local communities. However, the expansion of mining activities also has numerous effects on the agricultural sector, including changes in land use, soil and water quality deterioration, and increased pressure on the sustainability of agricultural output (Afriyie et al., 2023). These characteristics create an increasingly difficult livelihood situation for rice-farming households that still depend on agriculture as the primary source of subsistence. They face not just production problems, as a result of environmental changes, but also changes in the rural economic structure, increasingly driven by the extractive sector. In such situations, access to food by households is a key element of their survival strategy and contributes to the sustainability of their livelihoods.

The main conceptual framework used for understanding how households respond to these situations is the Sustainable Livelihood Framework (SLF) (Bebbington, 1999; Ellis, 1999; Scoones, 1998). From the SLF perspective, the success of a household in maintaining well-being depends not only on the level of stress they confront but also on their ability to respond to these pressures through diverse livelihood strategies. This theory considers households as actors who actively combine resources, economic opportunities, and adaptation strategies to attain the livelihood outcomes they desire. The SLF also contextualises numerous external shocks, environmental change, economic volatility, and extractive activities as part of the vulnerability context that can shape household livelihood strategy choices and outcomes. Therefore, the capacity to maintain food access in this study is interpreted as a livelihood outcome that indicates the household's ability to cope with the stresses and uncertainties they confront.

According to the SLF, a household's ability to sustain its livelihoods is heavily determined by its capability to access economic opportunities and respond to environmental and market variations (Ellis, 1999; Scoones, 1998). Two such capacities that have attracted much attention in the literature are market access and adaptive strategies. Market access allows households to

profit from agricultural products, cuts transaction costs, and broadens economic opportunities that can help sustain livelihoods (Ahmed et al., 2017; Marion et al., 2024; Seng, 2016). Meanwhile, adaptation strategies such as farm diversification, application of agricultural technology, and the development of alternative income sources are essential in enhancing households' ability to cope with various stresses and uncertainties (Ansah et al., 2023; Murendo et al., 2025; Muriuki et al., 2024). Studies have indicated that households with more adaptive capacity tend to be more resilient to external disturbances, being able to maintain well-being and access to basic needs, including food.

Despite the growing literature on extractive industries and rural livelihoods, evidence remains limited on how agricultural households maintain food access when extractive and climatic pressures coexist. Studies of mining-affected rural areas have largely examined environmental degradation, land-use change, and livelihood transformation, whereas livelihood resilience studies have emphasised market participation, diversification, and adaptation as mechanisms through which households cope with shocks and uncertainty (Adranyi et al., 2023; Ansah et al., 2023; Marion et al., 2024; Murendo et al., 2025; Obodai et al., 2024; Ofosu et al., 2020). These strands of research are relevant to the same household livelihood system, yet they are often examined separately.

Although objective conditions, such as agricultural production, distance to markets, farm income, and food expenditure, are important for assessing household livelihoods, they do not fully capture how households interpret the constraints and opportunities that they face. Livelihood decisions are made under uncertainty and are informed by households' appraisals of environmental risks, economic opportunities, and their own capacity to respond. In this sense, perceptions are not treated as interchangeable with objective conditions; rather, they represent the cognitive and evaluative processes through which households interpret those conditions when making livelihood decisions.

This perception-based approach is consistent with research on adaptation behaviour, which shows that risk appraisal and perceived adaptive capacity shape whether and how individuals respond to environmental pressures (Grothmann & Patt, 2005). Within the Sustainable Livelihood Framework, households are therefore understood not merely as possessing assets or facing vulnerabilities, but as actively interpreting their livelihood context and selecting responses on the basis of the opportunities and constraints that they perceive. Perceived mining impacts and perceived climate variability capture households' appraisal of vulnerability pressures; perceived market access captures their appraisal of accessible economic opportunities; and adaptation strategies capture their reported behavioural responses. PCMFA consequently reflects perceived confidence in maintaining food access under those conditions, rather than objectively observed food-security status.

Drawing on this perception-based application of the Sustainable Livelihood Framework, this study distinguishes between vulnerability context and livelihood capacity. Perceived mining impacts and perceived climate variability represent household perceptions of vulnerability pressures that may constrain agricultural livelihoods. In contrast, perceived market access and adaptation strategies represent livelihood capacities through which households may mobilise economic opportunities, adjust their practices, and buffer external pressures. Perceived Capacity to Maintain Food Access (PCMFA) is therefore positioned as a perceived livelihood outcome, rather than as a direct measure of household food security. This framework enables the study to examine whether variation in PCMFA is more strongly associated with perceived vulnerability pressures or with livelihood capacities.

Accordingly, this study investigates the associations of perceived mining impacts, perceived climate variability, perceived market access, and adaptation strategies with PCMFA among lowland rice-farming households in Bangka and South Bangka Regencies, Indonesia. The study contributes to the application of the Sustainable Livelihood Framework in extractive settings by showing how households' perceived capacity to maintain food access may be

shaped not only by exposure to environmental pressures, but also by their capacity to access markets and adapt their livelihoods. Importantly, the analysis does not assume that non-significant associations between vulnerability pressures and PCMFA indicate that mining and climate pressures are unimportant; rather, it examines whether their direct associations with PCMFA remain evident when livelihood capacities are considered.

2. Literature Review & Hypothesis Development

2.1 Sustainable Livelihood Framework and Livelihood Resilience

The study employs the SLF as a conceptual framework to explore how rural people sustain their livelihoods under different environmental and economic stressors. The household livelihood outcomes are dictated not only by the resources they possess, but also by their ability to adjust to changes and uncertainties emanating from the external environment (Bebbington, 1999; Ellis, 1999; Scoones, 1998). In this sense, households are considered active agents in the use of resources, economic opportunities, and livelihood strategies to attain desired goals.

The SLF includes the vulnerability context, which refers to the different pressures and uncertainties that might influence the choices and consequences of household livelihood strategies. These pressures may emanate from activities related to mining and climate variability, which affect agricultural production systems and access to productive resources in extractive sectors (Adranyi et al., 2023; Luning, 2014; Obodai et al., 2024; Ofosu et al., 2020). But the SLF also emphasises that livelihood outcomes are not only a function of the constraints faced but also the household's ability to respond to the stresses through access to economic opportunities and appropriate adaptation strategies.

This perspective corresponds with the literature on livelihood resilience, which emphasises the importance of household capacity to foresee, respond to, and adjust to diverse shocks without compromising the ability to satisfy basic requirements (Ansah et al., 2023; Murendo et al., 2025; Muriuki et al., 2024). In this study, the capacity to maintain food access is conceptualised as a livelihood outcome, which represents the ability of a household to retain appropriate food supplies, avoid food shortages, and access nutritious food. In explaining the ability of households to maintain access to food, this study makes a distinction between elements from the vulnerability context and factors from the livelihood capacity viewpoint, on the basis of this perspective.

2.2 Perceived Mining Impact and Ability to Maintain Food Access

From the SLF perspective, mining operations are among the components of the vulnerability context that might affect the sustainability of household livelihoods. Previous studies have shown that extractive operations influence land use change, deteriorate the quality of natural resources, and impair environmental support for agricultural activities (Adranyi et al., 2023; Obodai et al., 2024; Ofosu et al., 2020). Such changes could increase pressure on households that depend on the agriculture sector as their main source of livelihood. When households perceive a greater influence of mining on their agricultural activities, their capacity to maintain their livelihoods and food access can be compromised. Perceptions of mining consequences are therefore likely to be negatively connected to household capacity to maintain food access.

H1: Perceived mining impacts are negatively associated with perceived capacity to maintain food access.

2.3 Perceived Climate Variability and Ability to Maintain Food Access

Agricultural households are subject to pressures stemming from climate uncertainties in addition to extractive activities. Climate variability can affect agricultural production by altering rainfall patterns, changing planting seasons, and raising the risk of disruptions to agricultural activities (Ansah et al., 2023; Murendo et al., 2025; Muriuki et al., 2024). These variables are a vulnerability setting within the SLF framework that might affect a household's ability to achieve desired livelihood outcomes.

Households with higher perceived climate uncertainty are more exposed to threats to their agricultural activities and sources of income. As a consequence, their capacity to maintain adequate food inventories, steer clear of food shortages, and access healthy food could diminish. Thus, perceptions of climate variability are likely to be negatively associated with household capability to maintain food access.

H2: Perceived climate variability is negatively associated with perceived capacity to maintain food access.

2.4 Perceived Market Access and Ability to Maintain Food Access

The SLF stresses that household life outcomes are not only influenced by the constraints they experience but also by their capacity to take advantage of existing economic possibilities. One crucial capacity for farm households is access to the market. Market access allows households to acquire information, market their output, get production inputs, and develop economic prospects that can promote sustainable livelihoods (Ahmed et al., 2017; Marion et al., 2024; Seng, 2016).

The literature suggests that households with more perceived market access tend to have stronger economic capacities and are better equipped to meet their fundamental necessities. In extractive areas, access to markets can assist households in buffering the impacts of economic and environmental instability by boosting chances to generate income and preserve livelihoods. Therefore, perceptions of market access are hypothesised to be positively connected to household capacity to maintain food access.

H3: Perceived market access is positively associated with perceived capacity to maintain food access.

2.5 Adaptation Strategies and Capacity to Maintain Food Access

Adaptation strategies are a type of livelihood capacity that allows households to respond to environmental and economic changes. From the perspective of SLF and livelihood resilience, households that can adapt their livelihood practices through diversification of their businesses, changes in their cultivation practices, or by developing alternative sources of income tend to be better able to cope with various stresses and uncertainties (Ansah et al., 2023; Egamberdiev et al., 2023; Murendo et al., 2025).

Higher adaptive capability helps households to keep their revenue sources, reduce risk exposure, and preserve livelihoods. In extractive sectors under simultaneous environmental and economic pressures, adaptation strategies are seen to be vital in helping households maintain access to food. Hence, adaptation strategies are likely to be positively correlated with the capacity of households to maintain access to food.

H4: Adaptation strategies are positively associated with perceived capacity to maintain food access.

3. Methodology

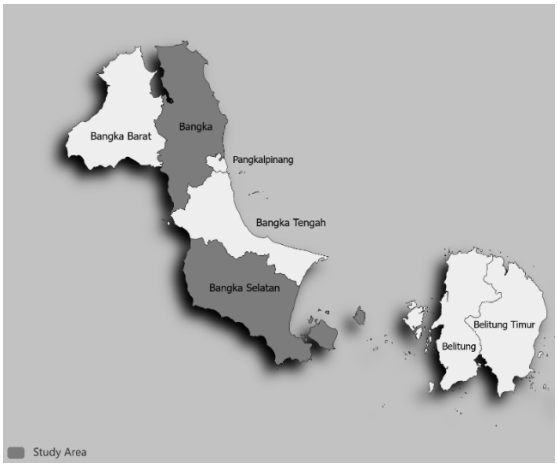
3.1 The Study Area and Data Collection

This study was conducted in Bangka and South Bangka Regencies, Bangka Belitung Islands Province, Indonesia. These two regencies were purposively selected because they are important centres of lowland rice production on Bangka Island and possess characteristics directly relevant to the research aims. Based on data from Statistics Indonesia (BPS-Babel, 2024), South Bangka produced 65,029.61 tonnes of paddy, and Bangka produced 4,943.99 tonnes, making them the two largest rice-producing regencies on Bangka Island. Both regencies also experience significant interaction between the agricultural sector and tin mining, and the selected rice-farming communities are located close to active tin-mining sites and former mining areas. These conditions make the two regencies appropriate locations for examining households' perceived capacity to maintain food access under extractive pressure (Supriyanto et al., 2022).

Primary data were collected through a structured household survey conducted from June to July 2025. The study population consisted of active lowland rice-farming households in the selected areas. Respondents were recruited through purposive and snowball sampling because no complete sampling frame was available for active lowland rice-farming households located in mining-affected communities. The eligibility criterion was active engagement in lowland rice farming at the time of the survey. Two locally resident enumerators were engaged, one in Bangka Regency and one in South Bangka Regency. Recruitment began with two eligible initial contacts, one in each regency, identified by the respective enumerator through familiarity with the study community. Each initial respondent referred other potentially eligible farmers, and subsequent referrals were obtained from previously interviewed respondents. Each referred farmer was screened against the same eligibility criterion before being interviewed.

Before fieldwork, 96 interviews were set as a minimum operational target using the Lemeshow sample-size calculation. Because the study used a non-probability design, this target was not treated as a basis for statistical representativeness or population-level precision. Recruitment continued after the target had been reached because 11 additional referred farmers met the eligibility criterion and were available for interview. The final sample therefore comprised 107 households: 57 in Bangka Regency and 50 in South Bangka Regency.

Figure 1. Study Area



No formal saturation criterion was applied. Although a two-seed design was used, with one initial contact in each regency, each referral chain originated from a single initial contact and may therefore have concentrated respondents within connected social networks. This may have introduced selection bias. The study sought to reduce this concern by applying the same eligibility criterion to all referrals and by covering both Bangka and South Bangka Regencies. Nevertheless, the findings should be interpreted as evidence from the surveyed households rather than as statistically representative estimates for all rice-farming households on Bangka Island.

3.2 Ethical Considerations

This research has been assessed and certified to be ethically sound by the Research and Community Service Institute (LPPM) of Bangka Belitung University (Ethical Clearance Number 1651/UN50/M/TU/2025) granted on June 2, 2025. It was a household socio-economic survey that posed minimal risk. All participants gave freely informed consent before the interviews, and absolute confidentiality and anonymity of responders were ensured.

3.3 Measurement of Variables

This study employs one dependent variable and four independent factors. All items are rated on a five-point Likert scale from 1 (strongly disagree) to 5 (strongly agree) and summed to form the composite score for each variable. The dependent variable of this study is Perceived Capacity to Maintain Food Access (PCMFA). Unlike more comprehensive instruments such

as the Household Food Insecurity Access Scale (HFIAS) or the Food Insecurity Experience Scale (FIES), the PCMFA used in this study does not aim to measure all dimensions of food security, but rather to capture household capacity to maintain food access in the context of extractive pressures faced by lowland rice farmers.

Because the focal variables were collected through self-reports from the same respondents, procedural measures were applied during questionnaire administration to reduce the risk of common method variance. Respondents were informed that participation was voluntary and that their identities and responses would remain anonymous and confidential. The questionnaire used clear and easily understandable language, and the item groups representing vulnerability pressures, livelihood capacities, and PCMFA were presented in separate sections. These procedures were intended to reduce evaluation apprehension and respondents' tendency to provide consistent answers across constructs (Podsakoff et al., 2003). Nevertheless, the use of a single respondent and a single cross-sectional questionnaire means that common method variance and correlated perceptions cannot be fully ruled out. The reported coefficients should therefore be interpreted as associations and with appropriate caution.

Table 1. Definition and Measurement of Variables

Variables	Operational Definition	Conceptual Indicators	Items	References
Perceived Capacity to Maintain Food Access (PCMFA)	Rice-farming households' perceptions of the ability to maintain adequate food access under environmental and livelihood pressures	Food access capacity	(1) Availability of food stocks during difficult times; (2) Rarely experiencing food shortages; (3) Able to access nutritious food	(Calloway et al., 2022; Jubayer et al., 2023; Marques et al., 2014; McKay et al., 2023; Yamaguchi et al., 2022)
Perceived Mining Impacts (PMI)	Rice-farming households' perceptions of agricultural resource degradation due to mining activities	Mining-induced agricultural resource degradation	(1) Declining soil quality; (2) Declining water quality; (3) Reduced productive agricultural land	(Hosseinpour et al., 2022; Ioanna et al., 2023; Tang et al., 2025; Zhang et al., 2023)
Perceived Climate Variability (PCV)	Rice-farming households' perceptions of climate uncertainty affecting agricultural activities	Perceived climate uncertainty	(1) Disruption of agricultural productivity; (2) Difficulty predicting planting seasons	(Degefu & Kifle, 2024; Habib-Ur-Rahman et al., 2022; Kerebo et al., 2025; Lemi & Hailu, 2019)
Perceived Market Access (PMA)	Rice-farming households' perceptions of their ability to access and benefit from agricultural markets	Perceived market accessibility	(1) Ease of selling agricultural products; (2) Favourable price; (3) The market is easy to reach	(Alam et al., 2025; Li et al., 2023; Ma et al., 2024; Ngubane et al., 2025; Tran et al., 2025)
Adaptation Strategies (AS)	Rice-farming households' responses to environmental and economic challenges in terms of agriculture and livelihood practices	Livelihood adaptation strategies	(1) Crop diversification; (2) Use of new technologies/methods; (3) Alternative sources of income	(Khan et al., 2020; Magesa et al., 2023; Mohamed Shaffril et al., 2024; Sertse et al., 2021)

3.4 Control Variables

To limit the possible bias due to the variations in the socioeconomic features of the examined rice-farming households, this study has included three control variables, namely, education level (ED), number of working family members (WFM), and rice-farming households' income (IC). These variables were chosen because they are generally accepted as variables that can influence a rice-farming household's capacity to maintain food access and respond to environmental and economic stresses.

ED was an ordinal variable ranging from never attended school (0) to higher education/university (4). WFM was defined as the number of working family members and was categorised as 1 = one working family member, 2 = two working family members, and 3 = three or more working family members. IC was measured by the categories of monthly income: 1 = less than IDR 1,000,000, 2 = IDR 1,000,000- IDR 2,499,000, 3 = IDR 2,500,000- IDR 3,500,000, and 4 = more than IDR 3,500,000.

The main focus of this study is on the associations of perceived vulnerability pressures and livelihood capacities with PCMFA. At the same time, all three control variables are included to ensure that the observed associations are not simply a reflection of differences in rice-farming households' socioeconomic characteristics.

3.5 Validity and Reliability of Instruments

Table 2. Measurement Quality of Study Constructs

Constructs	No. of items	Corrected item–total correlation	Cronbach's alpha	Scale construction
PCMFA	3	0.679–0.788	0.848	Sum of 3 items
PMI	3	0.965–0.983	0.988	Sum of 3 items
PCV	2	0.649–0.649	0.774	Sum of 2 items
PMA	3	0.453–0.819	0.811	Sum of 3 items
AS	3	0.436–0.665	0.702	Sum of 3 items

Note: All corrected item–total correlations were statistically significant at $p < 0.001$.

Source: Data processing result, compiled by authors (2026)

Prior to the main analysis, item validity and internal consistency reliability were assessed for all multi-item constructs. Item validity was evaluated using corrected item–total correlations, with values above 0.30 considered acceptable. As reported in Table 2, all items exceeded this threshold, ranging from 0.436 to 0.983, and were statistically significant at $p < 0.001$. Internal consistency was assessed using Cronbach's alpha, with coefficients ranging from 0.702 to 0.988. These values exceeded the minimum acceptable threshold of 0.70, indicating adequate internal consistency. The composite score for each construct was calculated as the sum of its respective Likert-scale items. Table 1 reports the construct definitions, item indicators, and supporting references, while the complete questionnaire wording is available from the corresponding author upon reasonable request.

3.6 Regression Analysis Model and Specification

The hypotheses refer to conceptual constructs; however, the empirical analysis operationalised these constructs as theory-driven observed composite indices. Each construct was measured using two or three conceptually specified Likert-scale items, and the item scores were summed to create a composite score. This approach was supported by the measurement assessment reported in Table 2: corrected item–total correlations ranged from 0.436 to 0.983, and Cronbach's alpha values ranged from 0.702 to 0.988. Thus, the composite scores were used as reliable summary measures of the corresponding conceptual constructs rather than as single-item proxies.

Data analysis was performed using Ordinary Least Squares (OLS) multiple regression to examine the associations of perceived mining impacts, perceived climate variability, perceived market access, and adaptation strategies with households' PCMFA. OLS was selected because

the study aimed to estimate direct conditional associations among interpretable composite indices, rather than to estimate a latent-variable structural model or indirect pathways. Summed multi-item Likert scales are commonly treated as approximately continuous for this purpose, particularly when they are used as composite indices rather than as single ordinal items (Boone & Boone, 2012; Norman, 2010). A structural equation modelling approach could also be appropriate for research designed to assess a latent measurement model and more complex structural pathways. However, such an approach was not required for the present study's association-focused research objective. The use of composite scores does not eliminate measurement error; therefore, the results are interpreted cautiously as associations involving measured indices. The empirical model utilised in this investigation is formulated as:

$$PCMFA_i = \beta_0 + \beta_1 PMI_i + \beta_2 PCV_i + \beta_3 PMA_i + \beta_4 AS_i + \beta_5 ED_i + \beta_6 WFM_{i+} \beta_7 IC_{i+} \varepsilon_i \quad (1)$$

Where PCMFA is Perceived Capacity to Maintain Food Access, PMI is Perceived Mining Impacts, PCV is Perceived Climate Variability, PMA is Perceived Market Access, AS is Adaptation Strategies, ED is Education, WFM is Number of Working Family Members, IC is Income, and ε is the error term.

Before estimation, diagnostic tests were conducted to assess residual normality, multicollinearity, and heteroskedasticity. These checks were used to assess key regression diagnostics. Because heteroskedasticity was detected, White heteroskedasticity-consistent robust standard errors were used for statistical inference. The analyses were conducted using SPSS and EViews.

4. Results and Discussion

4.1 Personal Characteristics of Rice-Farming Households

The 107 lowland rice-farming households that participated in the study are characterised in Table 3. Most of the respondents were above 30 years of age (90.7%), showing that mature and experienced farmers still dominate rice farming in the research area. With regard to gender, the majority of the respondents were males (86.9%), while the women constituted only 13.1% of the entire sample.

The education levels of respondents were fairly low. Most of the farmers had an elementary school education (61.7%), while a minor proportion of farmers had further education (1.9%). This is in line with the overall characteristics of agricultural households in rural areas, who still have limited access to formal schooling (Sudarma et al., 2024).

In terms of the number of working family members, most households had one working family member (55.1%), followed by two working family members (34.6%) and three or more working family members (10.3%). The majority of rice-farming households (69.2%) had an income range of IDR 1,000,000 to IDR 2,499,000 per month, and just 3.7% had an income higher than IDR 3,500,000 per month. This result reveals that a majority of the agricultural households are in the lower-middle income group (Ho et al., 2022).

Table 3. Characteristics of Rice-Farming Households

Characteristics	Bangka (n=57)	South Bangka (n=50)	All (n=107)
Age (years)			
≤ 24	1	3	4
25-30	1	5	6
>30	55	42	97
Sex			
Male	43	50	93
Female	14	0	14
Education			
No schooling	3	1	4
Primary school	30	36	66
Junior secondary school	12	3	15

Senior secondary school	10	10	20
University	2	0	2
Number of working family members			
1	25	34	59
2	23	14	37
≥ 3	9	2	11
Income (IDR per month)			
< 1,000,000	14	2	16
1,000.000 – 2,499,000	31	43	74
2,500,000 – 3,500,000	10	3	13
> 3,500,000	2	2	4
Land ownership			
Yes	49	43	92
No	8	7	15
Experience in farming (years)			
<5	12	15	27
5-10	13	17	30
>10	32	18	50

Source: Authors' survey data (2025)

Property ownership was relatively high: 86.0% of respondents owned their own farmland, and 14.0% farmed non-owned property. Moreover, respondents had extensive farming expertise. Nearly half (46.7%) had more than ten years of farming experience, 28.0% had between five and ten years of experience, and 25.2% had less than five years of experience.

The respondent profile should be considered when interpreting the regression results. Most respondents were adult male farmers, owned agricultural land, and had substantial farming experience. These characteristics may provide households with accumulated local knowledge, greater continuity of access to agricultural land, and established social or market networks that may support adaptive livelihood responses. However, these resources do not eliminate environmental pressures. The robust regression results showed that stronger perceived mining impacts were negatively associated with PCMFA, whereas perceived climate variability did not show a statistically significant direct association at the 5% level. Thus, the profile of the surveyed households may help explain their coping capacities, but it does not negate the relevance of mining-related pressures for perceived food-access capacity.

4.2 Descriptive Statistics of Study Variables

Table 4 presents the descriptive statistics for the study variables based on 107 rice-farming households. The mean PCMFA score was 12.56 on a possible range of 3–15, indicating that respondents generally reported a relatively high perceived capacity to maintain food access. This interpretation concerns perceived food-access capacity and should not be understood as a direct measure of actual household food security.

Table 4. Descriptive Statistics of Variables

Variables	Mean	SD	Min	Max
PCMFA	12.56	2.64	6	15
PMI	6.16	3.37	3	15
PCV	8.78	1.62	3	10
PMA	12.39	2.92	5	15
AS	12.34	2.61	5	15

Source: Data processing result, compiled by authors (2026)

The mean PMI score of 6.16 indicates that perceptions of mining-related degradation varied considerably across respondents, as reflected in the relatively large standard deviation and the full observed range of scores. The mean PCV score of 8.78 on a possible range of 2–10 indicates that respondents generally reported climate-related uncertainty affecting agricultural activities and the predictability of planting seasons.

PMA and AS showed relatively high mean scores, at 12.39 and 12.34, respectively. These results indicate that many surveyed households reported relatively favourable market access and the use of adaptation strategies, including crop diversification, new agricultural methods, and alternative income sources. Overall, the descriptive statistics indicate that rice-farming households faced varying perceptions of mining and climatic pressures while also reporting livelihood capacities that may be relevant to maintaining food access.

4.3 Diagnostic Tests of the Regression Model

Prior to interpreting the regression estimates, diagnostic tests were conducted to assess residual normality, multicollinearity, and heteroskedasticity. The results are presented in Table 5.

Table 5. Results of Model Diagnostic Tests

Testing	Statistics	Values	Criteria	Conclusion
Normality	Jarque–Bera	2.4985	$p > 0.05$	Normal
	Prob.	0.2867	$p > 0.05$	
Multicollinearity	Centered VIF	1.067–2.498	VIF < 5	No multicollinearity
Heteroskedasticity	Breusch–Pagan–Godfrey F-statistic	4.2166	$p < 0.05$	Heteroskedasticity detected; White robust standard errors applied
	Prob. F(7,99)	0.0000	$p < 0.05$	
	Obs*R-squared	24.5746	$p < 0.05$	
	Prob. Chi-Square(7)	0.0009	$p < 0.05$	

Source: Data processing result, compiled by authors (2026)

The Jarque–Bera test yielded a probability value of 0.2867, which is greater than the 0.05 significance level. Therefore, the null hypothesis that the residuals are normally distributed could not be rejected. This result indicates that the residual distribution did not significantly depart from normality.

Multicollinearity was assessed using centered Variance Inflation Factor (VIF) values. The centered VIF values were 2.206 for Perceived Mining Impacts (PMI), 2.498 for Perceived Climate Variability (PCV), 1.785 for Perceived Market Access (PMA), 1.495 for Adaptation Strategies (AS), 1.152 for Education (ED), 1.067 for Number of Working Family Members (WFM), and 1.163 for Income (IC). All VIF values were below 5, indicating that multicollinearity was not a concern in the estimated model.

The Breusch–Pagan–Godfrey test indicated the presence of heteroskedasticity. The probability values for the F-statistic and Obs*R-squared statistic were both below 0.05, indicating that the variance of the residuals was not constant across observations. Therefore, the subsequent regression results were estimated and interpreted using White heteroskedasticity-consistent robust standard errors. This correction retains the OLS coefficient estimates while providing robust standard errors, confidence intervals, and significance tests in the presence of heteroskedasticity.

4.4 Results of Regression Analysis

Table 6. White Robust OLS Regression Results for PCMFA

Variables	Coefficient	Robust Std. Error	Std. β*	t-Statistic	Prob.	95% CI
C	2.5516	1.7364	—	1.4695	0.1449	−0.894, 5.997
PMI	−0.1634	0.0580	−0.208	−2.8146	0.0059	−0.279, −0.048
PCV	0.3079	0.1585	0.189	1.9422	0.0550	−0.007, 0.622
PMA	0.3084	0.0737	0.341	4.1808	0.0001	0.162, 0.455
AS	0.3177	0.0864	0.313	3.6782	0.0004	0.146, 0.489
ED	0.2158	0.1491	—	1.4475	0.1509	−0.080, 0.512
WFM	−0.0402	0.1568	—	−0.2564	0.7981	−0.351, 0.271
IC	0.1503	0.2593	—	0.5798	0.5633	−0.364, 0.665
Observations				107		

R-squared	0.7420
Adjusted R-squared	0.7237
Robust Wald F-statistic	69.0374
Prob. (Wald F-statistic)	<0.001

Note: White heteroskedasticity-consistent robust standard errors were used. Std. β is reported for the four focal study variables to facilitate comparison of their relative associations with PCMFA. PMI = Perceived Mining Impacts; PCV = Perceived Climate Variability; PMA = Perceived Market Access; AS = Adaptation Strategies; ED = Education; WFM = Number of Working Family Members; IC = Income.

Source: Data processing result, compiled by authors (2026)

Table 6 presents the White robust OLS regression results for households' Perceived Capacity to Maintain Food Access (PCMFA). White heteroskedasticity-consistent robust standard errors were used because the Breusch–Pagan–Godfrey test indicated heteroskedasticity. The model was jointly significant based on the robust Wald F-statistic (Wald F = 69.037; $p < 0.001$). The model explained 74.2% of the variation in PCMFA, with an adjusted R-squared value of 0.724.

Perceived Mining Impacts (PMI) showed a negative and statistically significant association with PCMFA (β = −0.163; robust p = 0.0059; 95% CI [−0.279, −0.048]). This result indicates that households reporting stronger perceived mining-related degradation of agricultural resources also tended to report a lower perceived capacity to maintain food access. Therefore, H1 was supported.

Perceived Climate Variability (PCV) had a positive coefficient, but the association was not statistically significant at the 5% level (β = 0.308; robust p = 0.0550; 95% CI [−0.007, 0.622]). The direction was also contrary to the hypothesised negative association. Thus, H2 was not supported. This result indicates that, after accounting for the other variables in the model, perceived climate variability did not show a statistically reliable direct association with PCMFA.

Perceived Market Access (PMA) was positively and significantly associated with PCMFA (β = 0.308; robust p = 0.0001; 95% CI [0.162, 0.455]). Households that reported better access to markets, more favourable prices, and easier market reachability tended to report higher PCMFA. The standardised coefficient for PMA was 0.341, making it the strongest positive association among the focal variables. Therefore, H3 was supported.

Adaptation Strategies (AS) also showed a positive and statistically significant association with PCMFA (β = 0.318; robust p = 0.0004; 95% CI [0.146, 0.489]). Households reporting greater use of crop diversification, new agricultural methods, and alternative income sources tended to report higher PCMFA. The standardised coefficient for AS was 0.313, indicating the second-strongest positive association among the focal variables. Therefore, H4 was supported.

The coefficient magnitudes also indicate that the associations are practically meaningful within the observed variation in the sample. Because PCMFA, PMA, and AS were constructed as summed scores from three Likert-scale items, a one-point increase in the PMA score was associated with a 0.308-point higher PCMFA score, holding the other variables constant. Similarly, a one-point increase in the AS score was associated with a 0.318-point higher PCMFA score. Expressed in terms of the observed dispersion, a one-standard-deviation increase in PMA (2.92 points) corresponded to approximately a 0.90-point higher PCMFA score, whereas a one-standard-deviation increase in AS (2.61 points) corresponded to approximately a 0.83-point higher PCMFA score. Given that the standard deviation of PCMFA was 2.64 points, these associations represent roughly one-third of the observed variation in households' perceived food-access capacity. These estimates should be interpreted as associations rather than causal effects; nevertheless, they indicate that perceived market conditions and adaptive livelihood responses are substantively relevant to how surveyed households assess their ability to maintain food access.

Among the control variables, education, number of working family members, and income were not statistically associated with PCMFA. Overall, the results indicate that PCMFA among

the surveyed rice-farming households was negatively associated with perceived mining impacts and positively associated with market access and adaptation strategies. Although PCV had a positive coefficient, its association with PCMFA was not statistically significant at the 5% level.

4.5 Discussion

The robust regression results indicate that households' Perceived Capacity to Maintain Food Access (PCMFA) was associated with both vulnerability pressures and livelihood capacities. Perceived Mining Impacts (PMI) showed a negative and statistically significant association with PCMFA, whereas Perceived Market Access (PMA) and Adaptation Strategies (AS) showed positive and statistically significant associations. Perceived Climate Variability (PCV) had a positive coefficient, but its association with PCMFA was not statistically significant at the 5% level after applying White heteroskedasticity-consistent robust standard errors. From the Sustainable Livelihood Framework perspective, these findings suggest that perceived livelihood outcomes in extractive settings should be understood through the simultaneous roles of vulnerability context and livelihood capacity.

The negative association between PMI and PCMFA indicates that households reporting stronger mining-related degradation of soil, water, and productive agricultural land also tended to report a lower perceived capacity to maintain food access. This result is consistent with studies showing that extractive activities may reduce the quality and availability of agricultural resources, disrupt farming systems, and increase livelihood vulnerability among households that depend on agriculture (Adranyi et al., 2023; Obodai et al., 2024; Ofosu et al., 2020). In the Bangka context, the finding suggests that mining-related environmental pressures remain relevant to rice-farming households' perceived ability to maintain food access. Because PCMFA is a perception-based livelihood outcome rather than a direct measure of actual food security, the result should not be interpreted as evidence of actual food insecurity. Rather, it shows that perceived degradation associated with mining is linked to lower confidence in the ability to maintain adequate food access.

PCV did not show a statistically reliable direct association with PCMFA after robust standard errors were applied. Although the estimated coefficient was positive, its confidence interval included zero, and the robust probability value was slightly above the conventional 5% threshold. The result should therefore not be interpreted as indicating that climate variability improves households' perceived capacity to maintain food access. Rather, it indicates that perceived climatic uncertainty did not independently explain variation in PCMFA once perceived mining impacts, market access, adaptation strategies, and household characteristics were considered.

This finding does not contradict the broader literature showing that climate variability can disrupt agricultural production through changing rainfall patterns, uncertainty in planting seasons, and production risks (Ansah et al., 2023; Murendo et al., 2025; Muriuki et al., 2024). A possible explanation is that the consequences of climatic uncertainty for perceived food-access capacity may be buffered by households' livelihood responses. Access to irrigation, accumulated farming experience, crop and income diversification, alternative income sources, and locally developed adaptive practices may help households maintain confidence in their ability to obtain food even when they perceive climate-related disruption. Previous studies have similarly identified irrigation, diversification, and alternative income generation as mechanisms that can reduce vulnerability to climate-related shocks (Egamberdiev et al., 2023; Wouterse et al., 2022; Zakari et al., 2022).

In the Bangka context, rural households may combine rice farming with plantation activities, small-scale trade, livestock raising, aquaculture, and other non-farm activities in response to economic and environmental uncertainty (Herdiyanti et al., 2025; Sulista, 2019). Such livelihood arrangements may reduce dependence on rice production alone and may partly explain why perceived climate variability did not show a direct association with PCMFA.

However, irrigation access, farming experience, diversification intensity, and non-farm income were not directly measured in the present study. These explanations should therefore be interpreted as plausible mechanisms for future investigation rather than as empirically confirmed pathways.

PMA showed the strongest positive standardised association with PCMFA among the focal variables. Households reporting easier access to markets, more favourable prices, and better market reachability also tended to report greater confidence in their ability to maintain food access. Within the present study, this association should be interpreted as a relationship between perceived market conditions and perceived food-access capacity; it does not demonstrate that the households had better objectively measured food-security outcomes. Previous studies have linked market participation and market access to food purchasing power, dietary diversity, household consumption, and food-security outcomes in rural settings (Ahmed et al., 2017; Cele & Mudhara, 2022; Marion et al., 2024; Seng, 2016; M. A. Usman & Haile, 2022; M. Usman & Callo-Concha, 2021). These studies provide relevant contextual evidence, but the present analysis is limited to PCMFA as a perception-based livelihood outcome. In mining-affected rural areas, perceived market access may therefore represent an important livelihood resource associated with households' confidence that they can obtain food through market channels when needed.

AS also showed a strong positive association with PCMFA. Households reporting crop diversification, the use of new agricultural methods, and alternative sources of income tended to report higher PCMFA. This finding is consistent with the livelihood resilience literature, which views adaptation as a capacity through which households adjust their livelihood practices and manage uncertainty without relying on a single source of income or production system (Demisse et al., 2024; Kandel et al., 2024; Wouterse et al., 2022). Previous studies have also linked livelihood diversification, climate-smart agriculture, irrigation, and alternative income generation with improved food security outcomes and reduced vulnerability in other rural contexts (Ansah et al., 2023; Egamberdiev et al., 2023; Murendo et al., 2025; Zakari et al., 2022). In the present study, adaptation strategies were positively associated with PCMFA, indicating that households with more flexible livelihood responses tended to report a stronger perceived capacity to maintain food access.

Overall, the findings refine the application of the Sustainable Livelihood Framework in extractive settings. Mining-related vulnerability pressures were directly associated with lower PCMFA, indicating that environmental accountability and the protection of agricultural resources remain essential. At the same time, PMA and AS showed the strongest positive associations with PCMFA, highlighting the importance of livelihood capacities in helping households manage economic and environmental uncertainty. Thus, interventions in mining-affected rural areas should not rely solely on household adaptation or market integration. They should combine efforts to improve market access and adaptive capacity with measures to regulate mining impacts, rehabilitate degraded land, and protect agricultural water resources.

An additional interpretive caution concerns potential reciprocal relationships between PCMFA, perceived market access, and adaptation strategies. Households that already feel more capable of maintaining food access may be more confident in assessing market opportunities and their own ability to diversify, adopt new practices, or secure alternative income sources. Conversely, stronger perceived market access and adaptation may support greater confidence in maintaining food access. Unobserved factors, such as productive assets, social networks, irrigation access, farming experience, local infrastructure, and access to assistance, may also influence these perceptions simultaneously. Although White robust standard errors address heteroskedasticity, they do not resolve reverse causality or omitted-variable bias. The estimated coefficients should therefore be interpreted as conditional associations rather than as evidence of one-directional causal effects.

5. Conclusion and Suggestion

This study examined the associations of perceived mining impacts, perceived climate variability, perceived market access, and adaptation strategies with PCMFA among rice-farming households in Bangka and South Bangka Regencies. Using OLS regression with White heteroskedasticity-consistent robust standard errors, the results show that perceived mining impacts were negatively associated with PCMFA, whereas perceived market access and adaptation strategies were positively associated with it. Perceived climate variability was not statistically associated with PCMFA at the 5% level. Perceived market access showed the strongest positive standardised association among the focal variables.

From a Sustainable Livelihood Framework perspective, the findings indicate that both vulnerability pressures and livelihood capacities are relevant to households' assessment of their ability to maintain food access. However, the results concern PCMFA as a perception-based livelihood outcome; they do not provide evidence of objectively measured food-security conditions or one-directional causal effects. Mining-related environmental protection therefore remains necessary alongside interventions that strengthen market access and adaptive livelihood capacity.

The findings suggest that mining governance in agricultural areas should combine environmental protection with livelihood-strengthening measures. Because perceived mining impacts were negatively associated with PCMFA, local governments should coordinate agricultural, environmental, and spatial-planning functions to protect productive agricultural land and water sources from mining-related degradation, monitor environmental risks affecting farming areas, and prioritise rehabilitation of damaged land that is relevant to local agricultural livelihoods. Mining companies, including through corporate social responsibility programmes, can complement these public responsibilities by supporting rehabilitation, water-management facilities, demonstration plots, post-harvest facilities, and market-linkage initiatives in consultation with affected farming communities.

Because perceived market access showed the strongest positive association with PCMFA, agricultural extension services, farmer groups, and BUMDes should jointly strengthen practical market access. Relevant actions include regular dissemination of price and buyer information, collective marketing and product aggregation through farmer groups, improved access to transport and post-harvest handling, and local business arrangements that connect farmers with reliable buyers. These measures should be targeted to farming communities located near active and former mining areas, where environmental pressure may constrain agricultural production and market participation.

The positive association between adaptation strategies and PCMFA also indicates a need for locally grounded support for crop diversification, improved farming practices, water management, and feasible supplementary income activities. Agricultural extension workers can provide technical assistance, while farmer groups and BUMDes can facilitate collective learning, input access, small-scale processing, and local enterprise development. Mining-company CSR should support—not substitute for—public environmental obligations and should be designed collaboratively with local governments and community organisations. These recommendations are intended to strengthen the livelihood conditions associated with households' perceived capacity to maintain food access; they do not constitute evidence that any individual intervention will necessarily improve objectively measured food security.

6. Limitations and Future Research

Several limitations should be acknowledged. First, the study relied on perceptual measures of environmental pressures, livelihood capacities, and food-access capacity rather than objective indicators of household food security. In addition, the focal variables were collected from the same respondent through a single cross-sectional questionnaire. Although procedural

measures were implemented to reduce potential common method variance, shared response tendencies and correlated perceptions cannot be fully excluded. Consequently, the findings should be interpreted as associations involving households' perceived capacity to maintain food access, rather than as evidence of actual food-security outcomes or causal relationships. Future research should combine household perceptions with objective indicators, such as agricultural production, food expenditure, dietary diversity, and access to irrigation, and should draw on multiple sources of information where feasible. Consequently, the study cannot determine whether the reported perceptions correspond to households' actual food availability, dietary quality, food expenditure, or experience of food insecurity.

Second, the cross-sectional design does not establish the temporal ordering of the observed relationships or capture changes in household conditions over time. Potential endogeneity cannot be fully ruled out. For example, households with stronger PCMFA may simultaneously perceive market access and their own adaptation capacity more positively, while unobserved factors such as productive assets, social networks, irrigation, farming experience, local infrastructure, and access to assistance may influence the focal variables together. White heteroskedasticity-consistent robust standard errors improve the reliability of statistical inference in the presence of heteroskedasticity, but they do not address reverse causality or omitted-variable bias. Future research should use longitudinal designs, repeated household observations, and more detailed objective measures to examine the direction and dynamics of these relationships.

Third, purposive and snowball sampling may have concentrated respondents within connected social networks and limited the statistical generalisability of the findings beyond the surveyed rice-farming households. In addition, the model did not include several potentially relevant factors, such as distance to markets, participation in mining-related work, access to government assistance, household debt, and local infrastructure conditions. Future studies should incorporate these variables and use broader probability-based samples where feasible.

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Declaration of AI and AI-assisted technologies in the writing process

During the preparation of this work, the author(s) used ChatGPT (OpenAI) to assist with language refinement, manuscript editing, improvement of academic writing quality, and restructuring sections of the manuscript in response to reviewers' comments. After using this tool, the author(s) reviewed and edited the content as needed and take full responsibility for the accuracy, integrity, and content of the publication.

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