



PLANNING MALAYSIA:

Journal of the Malaysian Institute of Planners

VOLUME 24 ISSUE 3 (2026), Page 461 – 479

PLANS AND STRATEGIES FOR ADAPTATION TO CLIMATE UNCERTAINTY FOR TRADITIONAL SALT FARMERS ON THE NORTHERN COAST OF JAVA

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Abstract

People around the world have reached a consensus regarding climate change and the occurrence of climate-related extreme events. This phenomenon directly impacts the production of salt, a vital commodity for both consumption and industry. The northern coast of Java produces salt with high fluctuations due to these erratic weather changes. Most salt farming communities consist of traditional farmers, with only a few having adopted technological innovations. This study aims to: (1) identify the climate change vulnerability of salt farming households on the northern coast of Java, and (2) analyze the adaptation strategies implemented to meet their economic needs. The study employed the Livelihood Vulnerability Index – Intergovernmental Panel on Climate Change (LVI-IPCC) method. Community adaptation was examined through field surveys involving 180 traditional salt farmers. Primary data were obtained through participatory observation, in-depth interviews, and documentation, supplemented by secondary data from relevant agencies. The results indicated that the climate variability component was the dominant factor in the LVI, at approximately 0.698. Based on the IPCC vulnerability components (exposure, adaptive capacity, and sensitivity), the overall LVI-IPCC ultimate value was 0.152. Production obstacles and price fluctuations forced salt farmers to adapt by diversifying their livelihoods, such as working as fishermen, cultivating milkfish or shrimp, rice farming, or providing construction and transportation services. Wealthy farmers utilized social networks to engage in interregional salt trading. This livelihood diversification served as a critical strategy for farmers to survive production constraints and price volatility.

Keywords: Climate, Coastal, Salt Farmers, LVI, Defense Mechanisms, Java Indonesia

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INTRODUCTION

Salt is always needed by humans in everyday life, primarily for consumption and industrial purposes. In Indonesia, salt is generally produced in coastal areas by evaporating seawater on a piece of land with the help of wind and sunlight as sources of evaporation energy. However, studies on salt-tolerant plants (Andriyano et al., 2013; Antwi-Agyei & Nyantakyi-Frimpong, 2021; Helmi & Sasaoka, 2018) reveal that not all coastal areas are suitable as salt production sites. Potential salt-producing areas in Indonesia include the northern coast of Java Island, coastal regions of Madura Island, parts of the eastern coast of Bali Island, and regions extending to West Nusa Tenggara (NTB) and East Nusa Tenggara (NTT). Some salt production by salt farmers in these regions uses traditional methods that depend on the season (hot weather), while some entrepreneurs or salt factories have adopted technology. Unfavorable climatic conditions, frequently changing weather, and government policies that do not favor the people often lead to low salt production for traditional farmers. The best time to cultivate salt is generally in the dry season, from June to August. The number of salt farmers working on the ponds varies; usually, one hectare of a pond can be cultivated by two to five farmers. Making salt takes approximately three to seven days. The process is faster if the weather is hot; otherwise, if the weather is changeable, it takes longer. The salt produced is 'krosok' salt and is usually sold by pond owners to middlemen.

Pond cultivators do not take part in the salt buying and selling process; they only receive wages from the pond owner (Asnawi, 2015). These individuals face structural problems at the farmer (producer) level, the market, and within government policies. At the production level, farmers deal with an unfair profit-sharing system because all decisions depend solely on the landowner. Additionally, the salt market structure is monopolistic and controlled by the owners of capital. Furthermore, inadequate protection for salt farmers prevents them from maintaining and developing their business (Ehiakpor et al., 2016; Sudaryana & Pramesti, 2018). Weather anomalies also pose significant obstacles to production. Under these conditions, salt farmers on the northern coast of Java undertake several side jobs to earn income and make ends meet. These economic constraints cause them to choose safe ways to fulfill their subsistence. Subsistence security is a principle that is more active in the choices and values of farmers than in maximizing average yields.

Farmers are reluctant to take risks and focus more on efforts to avoid falling production, rather than on maximizing the expected benefits (Ellis, 1998). Based on the background above, this study addresses: (a) the dynamics of the economic life of traditional salt farmers in several districts, especially in the northern coastal areas of Java 'Pantai Utara Jawa (Pantura)', and (b) the strategies for meeting the economic needs of these traditional salt farmers. The lack of

protection from the government is thought to have positioned salt farmers as subordinates to the rulers and owners of capital. Consequently, salt farmers have become very dependent on capital owners who are very influential on the welfare of salt farmers (Farahdina & Waridin, 2016). These owners of capital in the traditional salt industry exert a very significant influence on the welfare of salt farmers (Fuadi et al., 2016).

Some plans or strategies to combat the adverse effects of climate change can be implemented through various capabilities, such as using multiple cropping systems, planting crops that can withstand months of rain or flooding, and diversifying livelihoods (Hahn et al., 2009). Every household inevitably strives to survive in order to meet their needs. A livelihood strategy represents an alternative economic activity that households engage in to survive, which is basically implemented by utilizing diverse sources of income (Hidayati & Suryanto, 2015). In the context of salt farming, however, these strategies face significant challenges; according to Mafongoya (2015), the extended rainy season severely threatened the salt ponds in several regional administrative areas of the northern coast of Java.

In general, traditional salt farmers in Southeast Asia are vulnerable to weather changes. This research used a combination of the Livelihood Vulnerability Index – Intergovernmental Panel on Climate Change (LVI-IPCC) and purposive sampling methods to explore the case of traditional salt farmers on the northern coast of Java, Indonesia. Although this method has limitations because it tends to provide a portrait of vulnerability at one point in time (case study) and does not describe the dynamics of changes in vulnerability in the long term, the results of the field investigation are expected to strengthen the government's role in carrying out positive interventions. Additionally, government assistance, including equipment as well as additional knowledge and skills, is anticipated to increase farmers' resilience in facing extreme weather.

Climate variability in the context of traditional subsistence farming households is a vulnerability that causes changes in the composition of farm incomes; therefore, actions are needed to manage this vulnerability. The objectives of this study are: (1) to determine the vulnerability of salt farming households to climate change on the northern coast of Java, and (2) to identify adaptation strategies implemented to meet their economic needs.

RESEARCH METHOD

Research Sites

The study areas were chosen because they serve as salt storage hubs along the northern coast of Java Island. The seven selected locations were Indramayu, Cirebon, Brebes, Demak, Pati, Karawang, and Sumenep Regencies (Madura Island) (see **Figure 1**). The field survey for sampling was conducted in selected

sub-districts representing these seven regencies. These sites were selected purposively because they are ecologically vulnerable, characterized by droughts and floods that occur irregularly each year.



Figure 1. Study location of sampling area (Source: RBI, BIG).

Method

Vulnerability analysis in this study used the Livelihood Vulnerability Index – Intergovernmental Panel on Climate Change (LVI-IPCC) method developed by Jones & Thornton (2003) and descriptive analysis. The use of the LVI-IPCC method referred to the resilience of livelihood capacity to withstand pressure and disturbance factors while maintaining or enhancing essential functions. There were seven main components in this LVI research: socio-demographic profiles, livelihood strategies, social networks, health, access to food, access to water, and climate change.

In accordance with Hahn et al. (2009) and Zainab & Shah (2024), the LVI vulnerability value ranges from 0 (least vulnerable) to 1 (most vulnerable). Furthermore, the weight values of the LVI components were classified into three IPCC components: exposure (climate variability), adaptive capacity (socio-

demographic profile, social networks, and livelihood strategies), and sensitivity (access to food, water, and health). The final vulnerability score ranges from -1 (lowest vulnerability level) to +1 (highest vulnerability level) (Equation 1).

$$\text{LVI} - \text{IPCCd} = (\text{ed} - \text{ad}) * \text{sd} \dots\dots\dots 1$$

Where:

LVI-IPCCd : Household vulnerability within the IPCC framework

Ed : Total exposure score (average climate variability component values)

Ad : Total adaptive capacity score (average value of social profile components of demography, social networks, and livelihood strategies)

Sd : Total sensitivity score (average value of food, water, and health components)

The interpretation of the final score is that a value approaching 1 indicates a more vulnerable community, thereby requiring government intervention in the form of policy and community-based responses to mitigate the existing vulnerability. Conversely, a value closer to -1 represents a society that is less sensitive to climate change. This study employed a descriptive analysis to explain the climate change conditions on the northern coast of Java and Madura Island and how these shifts affected salt farmers in the formation of vulnerability variables.

Furthermore, a survey of respondents in the field identified the economic strategies used by the community to survive. Respondents were selected purposively, specifically traditional salt farming households (owners, cultivators, and farm laborers) who had experienced changing weather. The sample size was 180 participants, consisting of 30 respondents from each district, representing seven districts. Primary and secondary data were required in this research. The data collection method was implemented through field observation techniques, interviews, and literature studies. Key informants were deliberately selected from various relevant sources or institutions, including farmer group leaders, farmer representatives, agricultural field extension officers, village government, the Maritime Service, and the District Agriculture Service. To determine the economic impact caused by climate variability (rainfall), an analysis of the livelihood structure was carried out. The livelihood structure of the farm households measured included the structure of income, expenditure, and savings. Salt farmer household income (Ys) was calculated by adding up income for one year based on Equation 2.

$$Y_s = \sum F_s + \sum OF_s + \sum NF_s. \dots\dots\dots 2$$

Where:

Y_s : Salt farmer household income/year

$\sum F_s$: Income or income comes from own ponds

$\sum OF_s$: Income derived from work wages, sharing system, within the scope of farmers

$\sum NF_s$: Income that is not derived from agriculture

Income referred to earnings from both agricultural and non-agricultural products, minus production costs. Household expenditure was calculated by adding up all food and non-food expenses, while savings were the result of income minus expenditures. After obtaining the income data from each respondent, a normal distribution curve was constructed to determine the classification level of the salt farming household strata. To identify the adaptation mechanism or pattern of farmer households in dealing with climate variability, a qualitative descriptive analysis was carried out. The adaptation mechanism analyzed was a strategy carried out either within the ponds and their surroundings or through the diversification of salt farming household livelihoods. The research data were presented in the form of narratives, graphs, and tables. The study was conducted in three stages, as shown in **Figure 2**.

The LVI-IPCC method and purposive sampling approach had limitations, as the index results depended on the availability and accuracy of primary and secondary data. To minimize these weaknesses, the following approaches were taken:

- a. Combining the LVI-IPCC with qualitative methods, such as Focus Group Discussions (FGD) and in-depth interviews.
- b. Utilizing time-series data to analyze vulnerability trends over time (historical).
- c. Increasing the number of respondents to improve data representativeness and broaden the sample area distribution; in this study, 180 household respondents were surveyed (which was within the recommended range of 100–200 respondents).

The combination of the LVI-IPCC method and the purposive sampling approach provided rich, context-specific insights into individual cases; however, it had limitations regarding the generalizability of findings and may have introduced elements of subjectivity into the results.

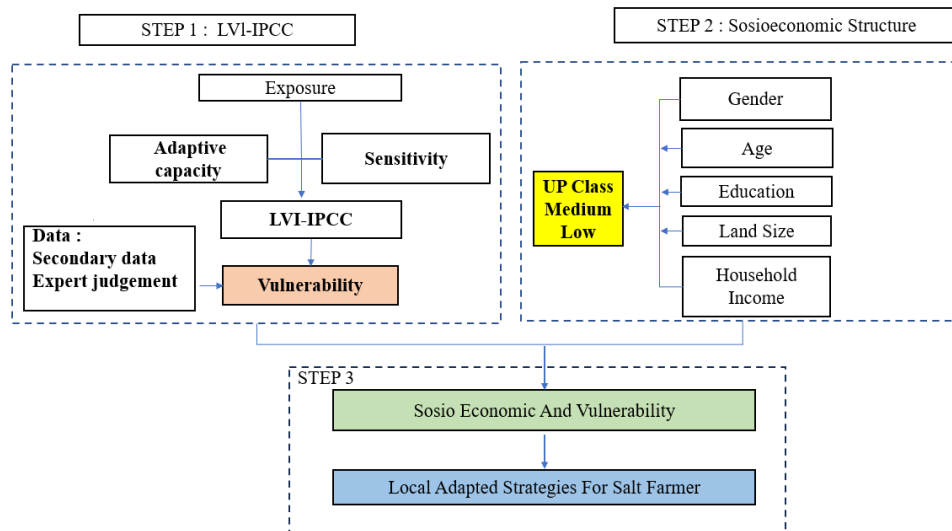


Figure 2. Research framework.

ANALYSIS AND DISCUSSION

Characteristics of Respondents

Field surveys for interviewing respondents were conducted in 2021. The total number of respondents in this study was 180 farmer households, with approximately 30 respondents representing each district. Respondents were, on average, between 40–60 years old, and the education level of most respondents was junior high school, with percentages of 56% and 44%. The average number of family dependents was 3–5 people. Respondents had varying land areas, ranging between 0.28 and 2.5 hectares. The status of land ownership was generally that of an owner (65%), while the rest were cultivators under a rental or profit-sharing system, or served as farm laborers.

Rainfall Variability

In 2022, increasing salt production became a priority as the industry began to recover following the COVID-19 pandemic. Programs receiving special attention included efforts to boost output through both integrated and traditional cultivation by incorporating membrane technology. In addition to technological advancements, production increases were achieved by monitoring water availability and accounting for weather factors (Karmilah, 2020). The average monthly rainfall in the study area is illustrated in **Figure 3**, where the highest average rainfall occurs in January, while the lowest is in September. Consequently, farmers generally conduct their activities from June to September.

Sometimes the onset of the rainy season comes a month or two months later; **Figure 3** illustrates that the dry season is June–October. The low rainfall criteria occur when the amount of rainfall is 0–100 mm per month. Meanwhile, the period of November–May is included in the medium rain category with rainfall of 101–300 mm per month. Variations in annual rainfall that cause salt planting or harvest failure are mainly related to global climate variations caused by El Niño events (Kifli et al., 2015).

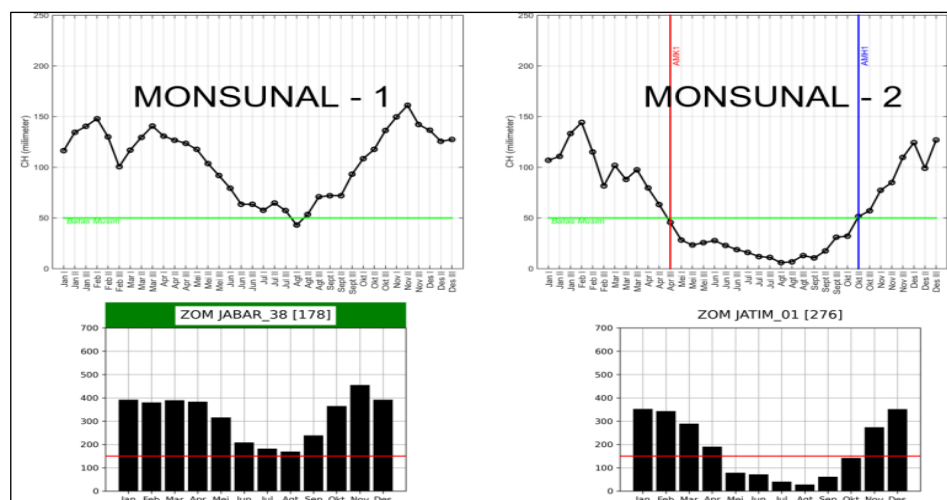


Figure 3. Annual rainfall variations influence the success or failure of salt cultivation (Source: BMKG, 2022).

Vulnerability of Livelihoods of Salt Farmers

Vulnerability was calculated using the LVI-IPCC method, which involved LVI calculations adjusted to the formulation of the Intergovernmental Panel on Climate Change (IPCC). The LVI, according to the IPCC (2014), indicates that vulnerability is influenced by exposure, sensitivity, and adaptive capacity. Salt farming households exhibited a high level of livelihood vulnerability, as demonstrated by the LVI-IPCC value of 0.152 for salt farming households throughout the northern coast of Java. The value of each parameter in the LVI-IPCC is presented in **Table 1**. Vulnerability indices are useful for monitoring vulnerabilities over time in each space. Identifying processes that contribute to vulnerability can be used to prioritize strategies to reduce it and evaluate strategies in social and ecological settings (Kim et al., 2017).

Table 1. LVI-IPCC values for the north coast salt farming households.

Parameter	Main indicators	Regency Index Value					
		Indramayu & Karawang	Cirebon	Brebes	Demak	Pati	Sumenep
Exposure	Natural Disasters & Climate Change	0.692	0.712	0.707	0.717	0.734	0.628
Adaptive Capacity	Socio Demographics Strategy & Social Network	0.254	0.243	0.241	0.253	0.201	0.214
Sensitivity	Food Water Land	0.321	0.351	0.312	0.315	0.339	0.345
LVI-IPCC		0.140	0.164	0.145	0.146	0.180	0.142

Based on the analysis in **Table 1**, farming households on the northern coast of Java were exposed to unpredictable climate variability. The value of vulnerability was greater in the eastern region; specifically, the higher the LVI-IPCC index value, the higher the level of vulnerability. Even though the exposure was higher, it could be offset by superior adaptive capacity in dealing with drought. A farmer's household is considered resilient and strong when it possesses adaptation strategies and extensive knowledge or insight to manage possible disasters and negative impacts caused by climate change (Novan Ngutra et al., 2017). The livelihood strategy was the most influential factor in augmenting the adaptive capacity of farming households on the northern coast.

Fluctuations in Salt Production and Household Income

Disasters during the rainy season caused most salt farming lands to experience an excess of freshwater in their ponds, resulting in low salinity levels and crop failure. Other factors influencing salt scarcity in the market were the uncertain climate and flooding in production areas, which triggered a crisis in industries dependent on this salt (Nirwansyah, 2021; Purwanti et al., 2022). Interview results showed that salt fields experienced production fluctuations between 90–120 tons/ha/season for wealthy farmers, while traditional salt farmers generally produced 50–80 tons/ha/season. In general, the primary constraints faced were price, weather, and the market.

Salt processing technology in the field generally included traditional methods (subsoil) and membrane technology (plastic). Some farmers utilized

isolators and sprinklers; while these were recognized for increasing production, they required significant investment. The primary challenges for salt production were rainfall and price instability. Consequently, farmers had to consistently receive weather information to ensure production certainty. The harvest season typically lasted between 3–4 months, starting in June. Furthermore, farmers required price standards to provide economic security for their production.

The largest cost component of the traditional salt business was labor, specifically processing costs (38.8%), harvesting costs (22.22%), and transport costs from the field to the roadside (11.11%). Processing labor costs were categorized as non-cash costs because the labor was provided by the salt farming households. Meanwhile, transportation and harvesting labor were classified as cash costs because they employed workers from outside the salt farming families.

The total income of salt farmers per hectare reached IDR 25,200,000–36,500,000 under favorable climatic conditions. With a total cost per hectare ranging from IDR 5,000,000 to 7,000,000, depending on the distance from the main road, the monthly average income was approximately IDR 1,650,000–2,458,000/ha. The results of the business analysis indicated a revenue-to-cost ratio (R/C) of 1.47, meaning that every rupiah spent by farmers in the salt business generated a revenue of 1.47 rupiah. Meanwhile, the profit-to-cost ratio of 0.47 indicated that for every additional rupiah spent, a profit of 0.47 rupiah was generated. This situation suggested that during that season, the traditional salt business was profitable.

According to public information, in 2014–2017, farmers enjoyed a good harvest season, while in 2017–2020, they were unable to harvest salt due to unfavorable weather and the COVID-19 pandemic, which disrupted production and price circulation. Traditional farming household respondents reported a yield of 50 tons/ha/season. Prices fluctuated significantly, ranging from IDR 350–750/kg on communal land, yielding an average income of IDR 25,000,000/ha/season. However, during the failed planting season in 2018, the average income decreased to IDR 12,500,000/ha. This decline in average income was due to exposure to climate variability, characterized by irregular droughts and rains that resulted in decreased salt production. Average monthly fluctuations in salt prices in 2017–2021 are shown in **Figure 4**.

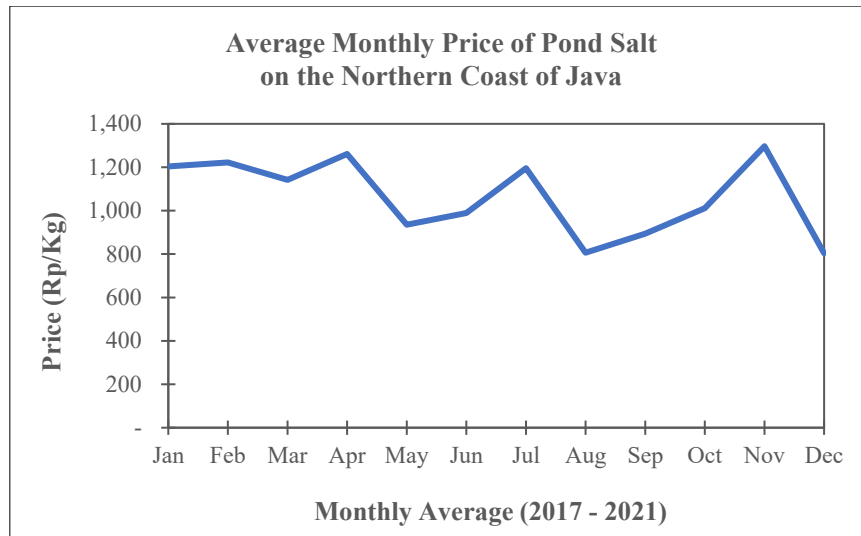


Figure 4. Average monthly price fluctuations of ready-to-transport salt during 2017-2021.

DISCUSSION

Farmer Household Livelihood Structure

A livelihood comprises assorted assets, activities, and access that together determine the living standards of individuals or households. Assets consist of various capitals owned by a household, including natural, physical, human, financial, and social capital (Nikmaturohmah, 2016; Shinbrot et al., 2019). The total income earned by a person reflects the resources required to generate that income. In accordance with Ellis (1998), there are three sources of income, collectively known as the income structure: farm, off-farm, and non-farm income. Farm income refers to income generated from farming on land one owns or operates through rent. Off-farm income refers to a farmer's income from wages or exchange of work in other agricultural fields, such as animal husbandry. Meanwhile, non-farm income refers to sources of income from outside the agricultural sector.

The results of the income structure analysis indicated that the income level of salt farming households on the northern coast was relatively good, with the bottom layer positioned just above the poverty line. The average total annual earnings of salt farming households on the northern coast ranged from IDR 17,720,000 to 40,900,750; this condition occurred under favorable or supportive climate conditions. Based on the calculation of the income structure, the stratification of farmer households was carried out. There were three categories of farmer households: upper, middle, and lower layers. Differences in the income

structure per layer, influenced by landownership and tenancy, are presented in **Figure 5**.

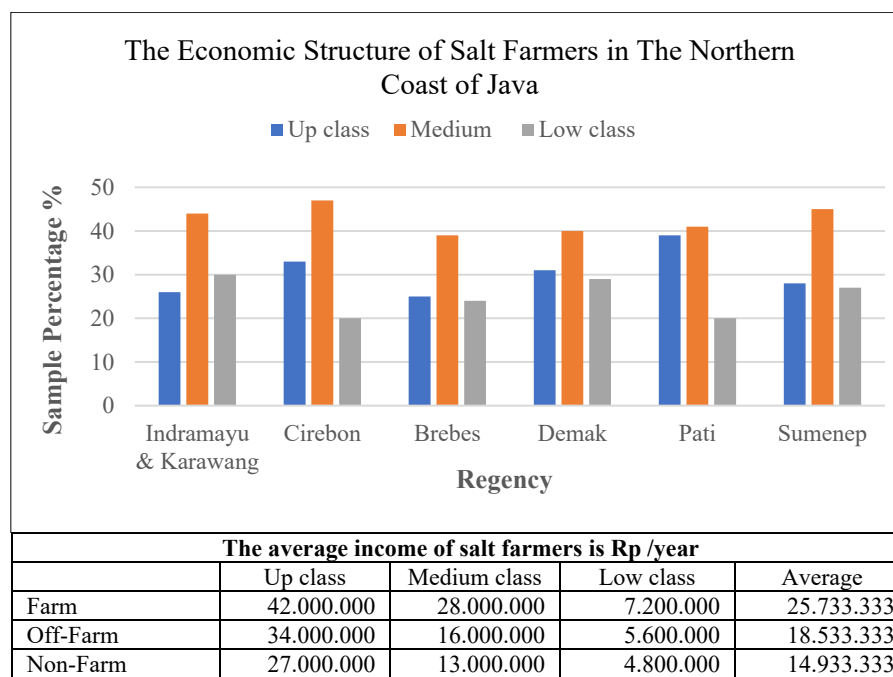


Figure 5. The income structure of salt farmers on the northern coast of Java.

Based on **Figure 5**, it was evident that most salt farming households also derived income from non-farm sources, including agriculture, animal husbandry, and fisheries. This indicated that respondents who usually worked as salt farmers also engaged in non-agricultural sectors under certain conditions. Income from the livestock sector at all household levels was derived from raising chickens, ducks, and laying ducks.

Meanwhile, income from fisheries was only found in the upper and middle layers, specifically through the cultivation of shrimp or milkfish ponds and salt trading between regions. The off-farm income of upper-class households was obtained from milkfish and shrimp farming. In 2017, the extended dry season benefited salt farmers. In contrast, lower-layer farming households depended more on off-farm sources, such as working as sharecroppers, harvest workers, and farm laborers. Sources of non-agricultural income included salaries from employment as temporary workers, tractor rental businesses, rice mills, land rentals, building supply services, and kiosks.

Salt Farmer Household Poverty Rate

The impact of climate change diminishes the production of salt and food crops, potentially leading to poverty (Junaid et al., 2023; Rochwulaningsih, 2012). In subtropical and tropical regions, yields generally decrease by 10–20 percent due to global warming and drought (Scott, 1981; Tran et al., 2022). The results reported by Shah et al. (2013) showed a close relationship between poverty and climate change, affecting approximately 1.3 billion poor people worldwide. Measuring household poverty levels can be performed using a variety of instruments. In addition to BPS calculations, the World Bank's poverty line measurement can be used, which is based on an income of USD 2.00, or the equivalent of IDR 28,000 per day.

Based on the interviews, it was evident that the bottom layer of the northern coast household respondents remained above the poverty line, with an average per capita income of approximately IDR 48,000 per day. Only the upper and middle layers were significantly above the poverty line. Poverty is not just a matter of income but involves human capabilities that should be able to develop; due to limitations within both the individual and the surrounding environment, individuals may be unable to achieve their full potential.

Salt Farmer Household Adaptation Pattern

The pattern of adaptation was defined as a strategy implemented by farming households to address the negative effects of climate variability. These patterns were grouped into three categories: economic, social, and ecological adaptation. Research by Syafi'i (2006) states that adaptation strategies can be implemented by farmers in drought-prone areas to mitigate the adverse impacts of climate change. Adaptation is critical to reducing the likelihood of climate variability impacts on smallholder farmers (Hasibuan et al., 2023; Thornton et al., 2008). Furthermore, Bhuyan et al. (2024) and Yasin & Ma'shum (2006) argue that the vulnerability of small farmers will continue to intensify without adaptation. Essentially, adaptation responses aim to decrease vulnerability and increase resilience, enabling farmers to become more resistant to climate variability. The findings of Zakki & Sayyida (2016) showed that households used various off-farm adaptation strategies, including changing occupational patterns, crop diversification, support from family and friends, adjusting household consumption patterns, and livelihood diversification. Ecological adaptation strategies were carried out by salt farming households in the Pantura by utilizing available natural resources, such as land and water. These adaptations included adjusting plant varieties depending on the season and improving irrigation. Farmers with sufficient land and capital often transitioned into shrimp or milkfish pond farming to generate income. The dominant social adaptation implemented by farming households involved utilizing social relations, such as borrowing

money from neighbors, relatives, or landowners, and utilizing government aid. The adaptive capacity of rural communities can be significantly strengthened if political, financial, and institutional support is targeted at households rather than at the individual or community level alone (Campos et al., 2014; Helmi & Sasaoka, 2018).

Respondents preferred to carry out social adaptation strategies based on mutual trust, while farmer groups primarily supported the procurement of subsidized fertilizers or seeds. Every farming household had a pattern of adaptation to cope with vulnerability resulting from climate variability, such as floods and droughts. To increase resilience, these households combined the three adaptation patterns. The specific pattern of adaptation carried out by a household depended on the livelihood capital available to them. Five types of livelihood assets can be utilized to maintain or enhance the level of capability to manage crises: human capital, social capital, natural capital, financial capital, physical capital, and government policy (Ellis, 1998; Nguyen & Bleys, 2023; Sudaryana & Pramesti, 2018).

Human capital was the second major challenge faced by farming households on the northern coast, after physical land capital, particularly for lower-level farmers. However, social networks (social capital) could compensate for low human capital in maintaining viability. The availability of capital influenced the capability of farming households to respond to the impact of climate variability. Mastery of natural capital by these households stemmed from land (rice fields or ponds), water, and other facilities for accessing natural resources, which supported their survival. The percentage of natural capital ownership varied, though the difference was minimal because most respondents were land-owning farmers. Specifically, the natural capital owned by farming households on the northern coast ranged from 1.15 to 2.5 ha of pond area. Salt farming workers were in the most vulnerable position; however, they accounted for only 18% of the sample and were accustomed to working part-time in motorcycle taxi services or as construction workers. Modification of traditional agricultural practices to diversify cultivation, efficient water management, and the improvement of other occupational skills were climate adaptation interventions specific to local conditions (Anzum et al., 2023; Dhanya et al., 2022; Kundu et al., 2024; Plaiphum & Tansuchat, 2023).

CONCLUSION

Climate variability had a detrimental impact on the household economy of salt farmers. The climate value was the most dominant variability component influencing the LVI, with an index value of 0.698. Based on the grouping of the seven LVI indicators into the IPCC vulnerability components (exposure, adaptive

capacity, and sensitivity), the ultimate value was 0.152. The various obstacles to salt production and price fluctuations led salt farmers to adapt by taking side jobs as fishermen, cultivating milkfish or shrimp, and engaging in rice farming, as well as providing construction and public transportation services in each district. Meanwhile, the salt farming households' annual income level on the northern coast ranged between IDR 17,720,000 and 40,900,750 under supportive climate conditions. Salt farming households implemented economic, social, and ecological adaptation patterns by utilizing available capital to mitigate the vulnerability arising from the negative effects of climate fluctuations. Ecological adaptation, which involves utilizing natural resources (land and water), is a key adaptation to salt farming. Economic adaptation includes utilizing savings, selling livestock, jewelry, or electronic goods, receiving transfers from families, and diversifying livelihoods. Finally, social adaptation involves utilizing social ties within society and accessing assistance from the government.

ACKNOWLEDGEMENT

The author expresses sincere gratitude to all individuals who participated in this study. Special appreciation is extended to the Head of the Research Center for Limnology and Water Resources at the National Research and Innovation Agency (BRIN) for the provision of data and laboratory facilities. Furthermore, the author acknowledges the Geospatial Information Agency (BIG) for providing the funding for the field survey. Finally, the author is grateful to the anonymous reviewers for their insightful comments and suggestions that improved this paper.

ETHICAL STATEMENT

This study was conducted in accordance with the ethical standards for socio-economic field research. Informed consent was obtained from all respondents prior to data collection. Participants were informed of the study's purpose, and their participation was entirely voluntary. To ensure confidentiality and privacy, all personal identifiers were removed, and the data were anonymized before analysis.

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Received: 20th May 2025. Accepted: 7th August 2025