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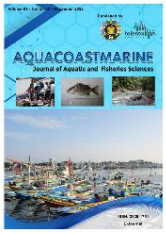

Assessment of Local Communities' Climate Vulnerability in Lampung: Case Study on Buffering Villages at Way Kambas National Park

Asesmen terhadap Kerentanan Iklim Masyarakat Lokal di Lampung: Studi Kasus pada Beberapa Desa Penyangga di Taman Nasional Way Kambas

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ABSTRACT

Communities in Lampung, Indonesia, are at the forefront of climate change impacts. Hence, this study aims to determine the climatic vulnerability of Lampung local communities. The study encompasses multifaceted aspects of climate exposure and its impact on the local communities of three resorts (Kuala Penet, Susukan Baru, Cabang). The analysis consists of examining historical climate patterns and how they correspond to the community's climate vulnerability. The analysis covers historical climate data from the period of 2004 to 2024, which includes the daily temperature (maximum, minimum, and average) and daily precipitation. Furthermore, interviews and Focus Group Discsussions are conducted to obtain information from the communities. The data is then interpreted by using the DPSIR framework. Inland and coastal communities differ regarding these aspects: risk exposure, sensitivity, and adaptive capabilities. For exposure, inland agricultural communities face risks from drought, soil degradation, and unpredictable rainfall. Meanwhile, coastal communities are affected by rising temperatures, rising sea levels, tidal floods, coastal erosion, and the depletion of fish stocks. Sensitivity is measured by means of livelihood, socioeconomic status, and access to healthcare. Marginalized groups, particularly the poor and elderly, face compounded risks due to limited healthcare access and displacement threats, with the most vulnerable being the coastal communities of Cabang Resort. Furthermore, when it comes to adaptive capabilities, both terrestrial and coastal communities in Lampung have very limited capacities to anticipate most of the climate change impacts. Strengthening climate resilience will require targeted interventions, including improvement of infrastructure, access to healthcare and disaster readiness programs.
Keyword: Climate change, Lampung, climate vulnerability, climate resilience, DPSIR

ABSTRAK

Masyarakat di Provinsi Lampung, Indonesia, merupakan salah satu kelompok yang paling terdampak oleh perubahan iklim. Penelitian ini bertujuan untuk menentukan tingkat kerentanan iklim masyarakat lokal di Lampung dengan mencakup berbagai aspek multifaset terkait paparan iklim dan dampaknya pada tiga wilayah tinjauan, yaitu Kuala Penet, Susukan Baru, dan Cabang. Analisis dilakukan dengan mengkaji korelasi antara pola iklim historis dan kerentanan masyarakat melalui penggunaan data iklim periode 2004–2024, yang meliputi suhu harian (maksimum, minimum, dan rata-rata) serta presipitasi harian. Selain itu, data primer diperoleh melalui wawancara dan Focus Group Discussion (FGD) untuk menangkap masyarakat. Dengan menggunakan kerangka kerja Drivers, Pressures, State, Impact, and Responses (DPSIR), hasil penelitian menunjukkan adanya perbedaan signifikan antara komunitas pedalaman dan pesisir dalam hal paparan risiko, sensitivitas, dan kapasitas adaptif. Komunitas agraris di pedalaman menghadapi risiko kekeringan, degradasi tanah, dan curah hujan yang tidak menentu, sementara komunitas pesisir terdampak oleh kenaikan suhu, kenaikan permukaan laut, banjir rob, erosi pantai, serta penurunan stok ikan. Tingkat sensitivitas, yang diukur melalui mata pencaharian, status sosial-ekonomi, dan akses kesehatan, menunjukkan bahwa kelompok marginal seperti penduduk miskin dan lansia menghadapi resiko berlipat, dengan kerentanan tertinggi ditemukan pada masyarakat pesisir di Resor Cabang. Lebih lanjut, baik komunitas daratan maupun pesisir memiliki kapasitas adaptif yang sangat terbatas dalam mengantisipasi dampak perubahan iklim. Oleh karena itu, penguatan ketahanan iklim memerlukan intervensi yang terukur, mencakup perbaikan infrastruktur, peningkatan akses layanan kesehatan, dan program kesiapsiagaan bencana.

Kata kunci: DPSIR, kerentanan iklim, ketahanan iklim, Lampung, perubahan iklim,

1. Introduction

As part of the equatorial region, Indonesia is at the forefront of climate change impacts. Lampung, one of its provinces, is not an exception. The province's geographic and socio-economic conditions make its communities inherently vulnerable to climate change, though the specific ways in which this vulnerability manifests may differ from other regions in Indonesia (Agus et al., 2021). Lampung is located on Sumatra, the westernmost of Indonesia's major islands, covering a total area of 33,575.41 km² (BPS Lampung, 2024). As the southernmost province of Sumatra, it is bordered by the Indian Ocean to the west and the Java Sea to the east. This geographic position exposes Lampung to a range of climate-related risks, from rising sea levels and coastal erosion to shifting rainfall patterns and extreme weather events. However, the impact of these risks extends beyond the environment, affecting the livelihoods and well-being of local (Rachmawati et al., 2022). Particularly for those settlements bordering the Way Kambas National Park, these climatic stressors may interact with anthropogenic land-use transitions. This overlap may potentially intensify the socioeconomic burden on nearby populations (Sundjaya & Syarifuddin, 2023).

Located at East Lampung regency, the Way Kambas National Park covering approximately 1,300 km² of lowland dipterocarp forest, swamp, and *Imperata* grassland. The area serves as a critical safeguard for regional climate resilience (Harapan et al., 2025). The eastern part of the national park is a coastal area which cover mangrove ecosystem as large as 3.724,11 ha in 2013. A significant decline compared with the 1983 cover that extended to 15.255,29 ha (Herman Yulianto et al., 2023). Beyond its fame as a home for endangered wildlife, notably the Sumatran Elephant (Subeno et al., 2025), the park functions as a vital provider of ecosystem services. Together, the terrestrial and coastal ecosystems act as essential carbon sinks (Choudhary et al., 2024; Wang et al., 2025) and regulators of local hydrological cycles (Cohen et al., 2010). For the buffering villages, these services are a lifeline, offering micro-climate regulation and water source protection that sustain local communities' livelihood (Nyangoko et al., 2021). However, the park also presents a complex dilemma that influences the adaptive capacity of local communities. This is because the proximity to the park creates a frontier of conflict. On one side, deforestation and habitat decline have forced wildlife into closer contact with human settlements (Tasya, 2025). While on the other side, when climate anomalies destroy crops or inducing high sea waves, communities may feel economic pressure to encroach further into the park. Of course, as the

consequence, communities must cope with failing yields due to weather while simultaneously losing assets to human-wildlife conflict. This dynamic creates a vulnerability trap, where the very presence of the protected area can also limit traditional adaptation options.

Lampung's population is broadly divided into inland and coastal communities, each facing distinct climate challenges based on their location and primary economic activities. Inland communities, largely dependent on agriculture, might be vulnerable to unpredictable rainfall, prolonged droughts, and soil degradation, all of which threaten crop yields and food security. Meanwhile, coastal communities, whose livelihoods rely on fishing and aquaculture, are at risk from rising sea temperatures, declining fish stocks, and saltwater intrusion. These compounding hazards are particularly critical for populations adjacent to the Way Kambas National Park, where regional climate variability, such as shifts in the Indian Ocean Dipole and ENSO, threatens to exacerbate existing anthropogenic pressures on land and water resources (Han et al., 2022). Specifically, the intricate intersection of forest encroachment and climate-induced resource scarcity necessitates an analysis of local adaptive capacities to mitigate potential livelihood collapse in these forest-fringe buffers. Furthermore, systemic economic instability arising from such environmental stressors can ripple through these communities, particularly when existing infrastructure lacks the resilience to buffer against high-frequency climate shocks (Desai et al., 2021) .

The effects of climate vulnerability in Lampung can be far-reaching, manifesting in food insecurity, loss of income, increased heat-related illnesses and waterborne diseases, displacement, rising living costs, and more frequent forest fires. As climate change intensifies, understanding these impacts and implementing targeted adaptation strategies will be essential to safeguarding the province's future. Hence, this study aims to determine the Lampung local communities' climatic vulnerability. The study covers multi-faceted aspects of climate exposure to the well-being of the Lampung local communities.

2. Methods

For a better understanding of how climate change may impact the local communities in Lampung, and in what specific way the local communities are vulnerable, the analysis is preceded by an analysis of climate patterns of the Lampung region. The analysis includes historical climate data of Lampung from the period of 2004 to 2024. The historical data obtained is the daily temperature (maximum, minimum, and average value) and daily precipitation. This time series data is then organized, cleaned and compiled for later processed using Python application. Python is utilized for its time series data analysis and visualization capabilities. To process the time series data into an observable trend, the Multiplicative Decomposition Method is employed, particularly for the daily temperature data. The method is preferred due to the assumption that the temperature steadily increases over time (Zebua et al., 2023).

The results from the climate data analysis are then used to assess the vulnerability of local communities in Lampung. The climate context also includes summary of future projection of Lampung climate, conducted by BMKG (The Meteorology, Climatology, and Geophysical Agency of Indonesia). Data collection related to the initial assessment of community vulnerability to climate change is conducted through literature review and in-depth interviews with community members and experts to identify community vulnerability to climate change. Interviews are conducted with respondents from representatives of several buffer villages around Way Kambas National Park in May 2024. The management divided the national park area into several smaller management units referred as Resort. For this study, there are three selected resorts within the park border, which are Kuala Penet, Susukan Baru, and Cabang (**Figure 1**). The study focuses on several villages in the proximity of these resorts. The selected villages are as follows: 1) Kuala Penet: Sukorahayu and Margasari, 2) Susukan Baru: Taman Fajar, Tegalyoso, Rantau Jaya udik II, and 3) Cabang: Way Seputih. Kuala Penet and Cabang resort represent coastal communities, whereas Susukan Baru represents terrestrial/inland communities.

Interviews and Focus Group Discsussions are conducted to obtain information related to climate change and community conservation behaviour. The data is then interpreted by using the DPSIR framework. The DPSIR is an acronym for the components of the framework which are Driver, Pressure, State, Impact, and Responses. This framework is a model that represents the causal effects of anthropogenic activities on the myriad states of the environment encompassing ecological, social, and economic impacts (Obubu et al., 2022). The framework also takes into account the importance of action responses, whether adaptation or mitigation.

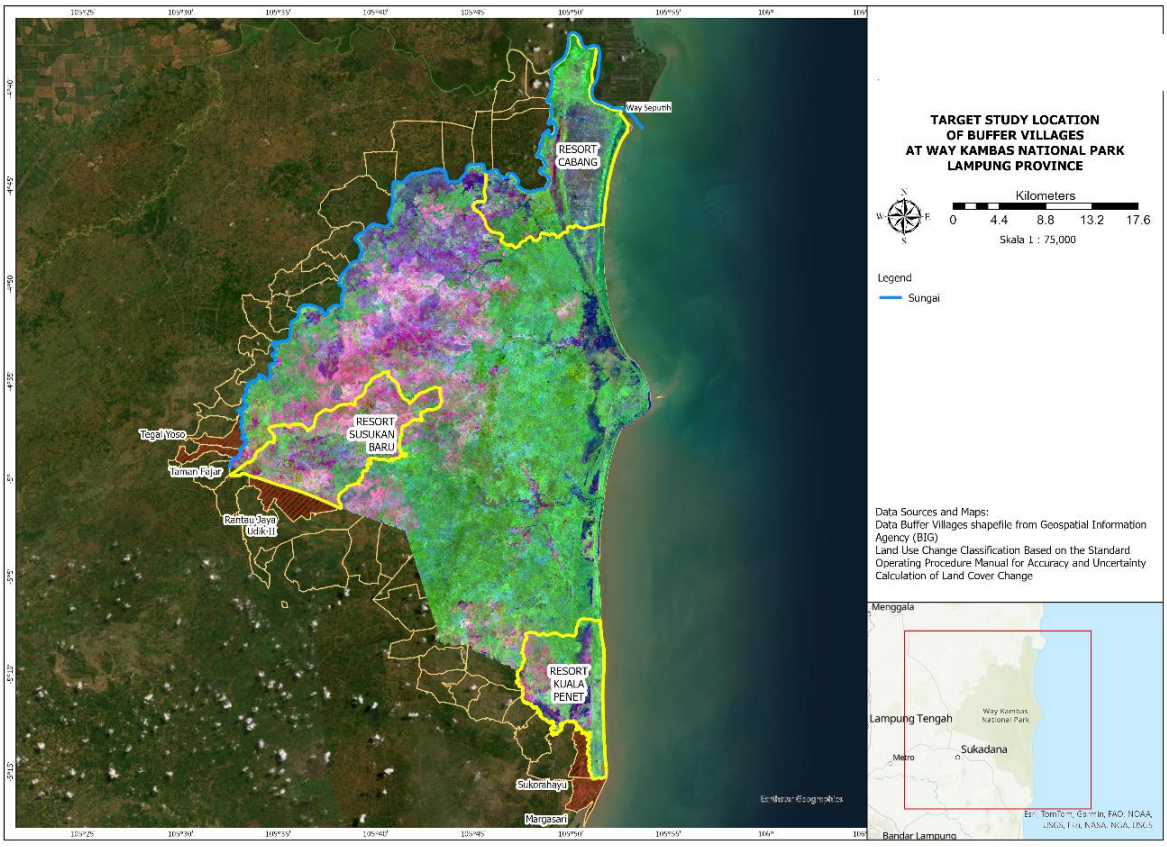

Figure 1. Target Study Location of Buffer Villages at Way Kambas National Park

3. Results and Discussion

3.1. Past and Future Climate Projection in Lampung Region

3.1.1. Lampung historical climate conditions

Below is a presentation of the dynamics of climate parameters from January 2004 to April 2024, which provides a reliable basis for understanding the climate change challenges the communities face. The parameters include average daily temperature, maximum daily temperature, and daily precipitation. This climate data series, a daily compilation, is sourced from BMKG, specifically from the Maritim Panjang Meteorology Station at Bandar Lampung.

As seen from **Figure 2**, the dynamic of the average temperature at Lampung does not seem to exhibit a distinctive pattern that implies the increasing temperature within a period of 20 years. Yet, when we look at the maximum temperature trendline, we see a shift in the threshold line from 2014 onward. From 2004 to 2014, the trendline tends to move across the 31.5 °*C* threshold. And then, in around 2016, the threshold gradually moved closer to 32.5 °*C*. The shift indicates an increase of approximately one ℃ in maximum temperature until the end of 2023. On the other hand, the minimum temperature displays an irregular pattern, in which from 2009 to 2015, the overall minimum temperature dropped to 21 ℃ level, down from 25 ℃ level in the subsequent years. The precipitation data shows that extreme rain in Lampung is relatively mild compared with other regions in Indonesia (**Figure 3**). However, it's important to note that Lampung has a unique state of vulnerability to extreme rains, as the last time the precipitation rate exceeded 200 mm was in 2013. For comparison, on 14 July 2021, South Kalimantan Climatology Station recorded 255.3 mm of precipitation. Another example is that in East Kalimantan, rainfall of 233 mm was recorded in 2018 (Badan Metereologi dan Geofisika, 2025). In Bandar Lampung, heavy rains have only reached 138.6 mm maximum for the last ten years. This historical data indicates that Lampung is less vulnerable than other Indonesian regions in terms of the impact of extreme rains. Still, the potential for future extreme rain events remains a significant concern.

Figure 2. The trend of temperature (Celcius) in Lampung Province for the period of 2004 - 2024

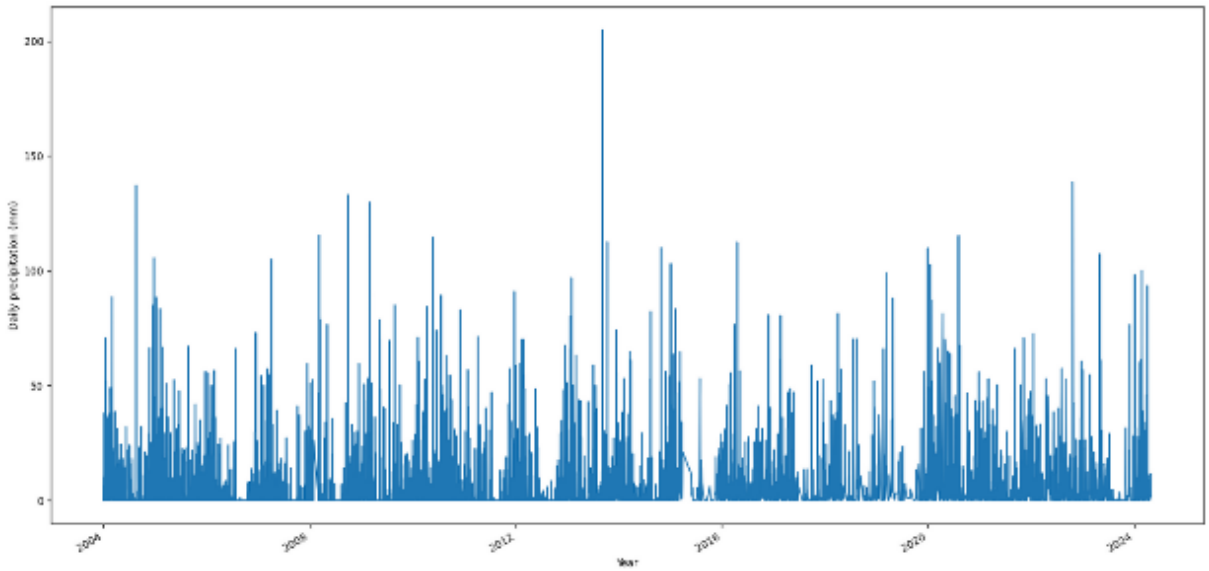

Figure 3. The distribution of daily precipitation (mm) in Lampung province for the period of 2004 – 2024

3.1.2. Lampung climate projection

BMKG has also developed a projection for climate indicators as the output of climate modelling under a consortium of CORDEX-SEA, of which BMKG is part. The modelling was run to project several climate indicators from 2020 to 2049 based on the data from 1976 to 2005. The model result is the degree of change mapped across the Indonesian region, including Lampung. The model is run based on two scenarios, RCP8.5 and RCP4.5.

The projection indicates a general warming trend with more pronounced temperature increases in terrestrial areas. Precipitation patterns are becoming more variable, with a tendency towards decreased seasonal precipitation yet an increasing probability of heavy to extreme rainfalls. Seasonal dry days will increase in terrestrial and coastal areas, with the terrestrial area experiencing a more significant increase. Coastal areas exhibit more regional variability in precipitation changes compared to terrestrial regions. The timing and length of wet seasons are also shifting, with some areas experiencing earlier starts and others facing reduced wet season lengths.

In summary, the terrestrial area's primary vulnerabilities will be significant temperature increases (especially maximum and minimum temperatures), more dry days, more possibilities of extreme rains, and decreased seasonal precipitation. For the coastal area, vulnerabilities include significant temperature increases, regional variability in heavy rain patterns, and shifts in wet season timing and length. Coastal regions also face added risks from sea-level rise and storm surges, exacerbating climate vulnerability. While both coastal areas face significant challenges, the combination of earlier wet seasons, reduced precipitation, and shorter wet seasons in the western coastal area presents more severe and immediate vulnerabilities than in the eastern coastal region.

3.2. Assessing Climate Change Impacts on Lampung Communities Using the DPSIR Framework

Based on an analysis of the climate trend during the 20 years (2004 – 2024) and the projection from CORDEX-SEA, it is evident that Lampung communities are also facing significant climate-related impacts. To comprehensively analyse and address the impacts of climate change on Lampung communities, we utilise the DPSIR (Drivers, Pressures, State, Impact, and Response) framework. This framework helps to systematically identify and understand the interconnections between the causes, consequences, and responses to environmental changes.

Since climate change is a global phenomenon, the driving causes may predominantly occur in certain regions, yet the effects would indiscriminately affect everyone across the globe. In particular to vulnerable communities that don't have sufficient means to alleviate the impact. Hence, the "driver" and "pressure "are broken down in the context of global scope, yet also tailored to the local context of Lampung, while "state", "impact", and "response" are limited to the local context. The framework above can be broken down into the following components.

- *Driver*. This aspect derives from the driving forces behind accelerating climate change, limited to anthropogenic (human) activities. According to the IPCC guidelines (2006), greenhouse gas emissions can be categorised based on four activities: energy-based emission, production processes and goods consumption, land-based emission, and waste-based emission. Aligns with the IPCC guidelines, the Action Plan Review document on the Reduction of Greenhouse Gas Emissions in Lampung Province 2021 (POKJA RAD-GRK Provinsi Lampung, 2021) by the Lampung Greenhouse Emission Reduction Taskforce includes six sectors as the drivers, namely agriculture, forestry and peatland, energy, transportation, industry, and waste management.

  Based on the document, deforestation due to land-use change is covered under the agriculture sector and the sectors of forestry and peatland. Land-use change is considered the main contributor to carbon emissions in these intersected sectors. In Way Kambas and the surrounding area, the human activities that drive deforestation are reportedly from:

  1) encroachment and illegal logging,
  2) poaching activities that involve burning forest areas,
  3) the conversion of mangrove areas into settlements, fishponds, and agriculture; mangroves are also threatened by poaching and timber extraction activities.

  Furthermore, energy-based emission activities in Lampung come from these three sectors: energy, transportation, and industry. These activities generally involve burning fossil fuels to produce electricity, running machines or vehicles, preparing food, etc.
- *Pressure.* This aspect derives from human activities' excess being pushed into the environment. In this case, pressure takes form as the release of greenhouse gases into the atmosphere. The greenhouse gases consist of six gasses, namely Carbon Dioxide (CO_2), nitrous oxide (N_2O), methane (CH4), Sulfur Hexafluoride (SF_6), Perfluorocarbons (PFCs), and Hydrofluorocarbons (HFCs)(Houghton et al., 2001).
- *State***.** This aspect derives from the environmental state or indicators that the pressure might impact. Based on the study, we formulate the most relevant states for Lampung's case study, covering environmental and societal states. Note that the latter is essentially the derivation of the former. The environmental states consist of changes in global temperature, changes in climate cycle/patterns, the occurrence of extreme events (very heavy rains, drought, or storm), and sea level. The societal states consist of a state of conflict with wildlife animals (elephants, monkeys, and boars), a state of conflict due to resource scarcity, human health and general well-being, and infrastructure vulnerability.
- *Impact*s. This aspect refers to when the environmental and societal states are pressured to fall into unfavourable conditions due to the ongoing pressures from human activities/drivers. We define

community climate vulnerabilities based on these impacts. Some impacts could be a result of an intertwining of several states. The impacts comprise as follows: food insecurity, loss of livelihood, increased heat-related illness, higher cost of living, and more prone to exposure to forest fire and its impact.

These impacts are based on the community's perceived vulnerabilities and observed changes. In addition, few impacts are based on literature reviews that are judged relevant to the case studies. For instance, loss of livelihood can be viewed as a further consequence of continuing food insecurity (Osman & Abebe, 2023). Displacement is a consequence when the intensity of extreme events (Ferris & Weerasinghe, 2020) have exceeded the capacity of the communities to withstand them. Hence, the loss of livelihood and displacement are framed as the impacts of climate change in the foreseeable future.

- *Response*. This aspect refers to the efforts made to mitigate the impacts and adapt to the changes brought about by climate change. Responses can be directed to the drivers, pressures, states, and impacts. They can be made by the communities impacted, the government, NGOs, and other related actors. Specifically, for communities, response is analysed as part of adaptive strategies to determine the communities' vulnerability.

3.3. Social vulnerabilities of communities in Way Kambas National Park

As mentioned before, the climate change impacts within DPSIR Framework that are related to social vulnerabilities in Lampung can be comprised as five aspects below. Before investigating the extent and dimension of social vulnerabilities, we should define social vulnerability as the function of risk exposure, sensitivity, and adaptive capacity (Khajuria & Ravindranath, 2012). Risk exposure and sensitivity are the indicators that correspond to the "impact" component in DPSIR framework. Whilst adaptive capability is the indicator that corresponds to the "response" component specific to the communities.

Risk exposure is the degree, duration, and magnitude to which a community or household is physically and geographically subjected to climate-related hazards. It acts as the external dimension of vulnerability, determined by the location and environment of the community in relation to the "State" and "Impact" factors identified in the DPSIR framework. Sensitivity, on the other hand, represents the internal susceptibility of the community to these exposures. It is influenced by the socio-economic characteristics of the population, such as their primary dependence on climate-sensitive livelihoods and their current state of health and well-being. Finally, adaptive capacity refers to the ability of the community to adjust to potential damage, take advantage of opportunities, or respond to the consequences of climate change. To sum up, social vulnerability encompasses multiple dimensions determining how communities experience and respond to climate change impacts. These components are interrelated and contribute to a community's overall vulnerability.

3.3.1. Food insecurity

Food insecurity refers to the condition in which people lack access to reliable food sources (Briones Alonso et al., 2018). The insecurity is not limited to the quantity per se but also covers the nutrient balance and diversity. Food security also extends to cultural values since it provides a sense of fulfilment required for a quality life.

Risk exposure. Food insecurity in Lampung is primarily caused by crop failure, which is likely induced by rising temperatures (Alotaibi, 2023; Li et al., 2025), the prolonged dry season, extreme drought, the shifting and the shortening of wet seasons, and conflict with wild animals (such as elephants, monkeys, and wild boars). Regarding rising temperatures, terrestrial crops face more significant temperature changes than coastal areas.

Lampung, in general, has less exposure to the events of extreme rains compared to other regions in Indonesia. This aligns with the fact that the communities have never experienced flood events that have caused damage to their properties or crop plants. For example, at Taman Fajar village, floods usually only occur in the nearby riverbanks. However, future projection reveals that the precipitation rate of heavy rains will likely increase, meaning that Lampung is not free from the risk of extreme rains in the future.

In addition, coastal areas are exposed to changes in extreme ocean wave heights. As global temperatures rise, the intensity of wind patterns can increase, leading to higher wave heights (Patra et al., 2021).

Sensitivity. Agricultural communities in terrestrial areas are more prone to face adversity due to crop failure (Touch et al., 2024). The communities have regularly experienced the impacts of prolonged dry seasons. According to the chief of Taman Fajar village, since 2020, the climate has become more unpredictable. The tendency is for dry days to occur more frequently than usual. This is particularly difficult for the communities that only rely on rainwaters for their agricultural needs.

Aside from water scarcity, more dry days bring up another problem. Rat infestations thrive in these dry conditions and have become a significant pest (Richardson et al., 2025). In addition, due to the buffering villages' close proximity to the Way Kambas National Park, it should be noted that there is already pre-existing conflict with wildlife animals. Their settlements and agricultural fields were once part of the natural wildlife habitat. Naturally, this has led to frequent encounters with various wildlife, including larger animals such as elephants, wild boars, and monkeys, all seeking food and water from the cultivated lands. With the shrinking habitats and diminishing food sources exacerbated by prolonged droughts, wildlife animal activities in human settlements and agricultural fields might intensify. In fact, there are reports that monkeys go far deeper than usual into agricultural fields during drought. In the future, with the dry season projected to be longer, the intensity of the conflict is prone to escalating.

More heavy rains in the future also pose a risk to crop cultivation (Iizumi et al., 2024). For instance, cassava is one of the important crops in Lampung, and it is very susceptible to damage in the wet season. Farmers reported that during periods of intense rainfall, cassava roots often rot, leading to significant losses. This rotting of cassava, or "busuk singkong," affects not only the yield but also the quality of the produce, making it less marketable and reducing the overall income for farmers. Heavy rains also intensify pest presence, particularly caterpillars, which damage rice and corn crops.

The coastal communities that rely on fishing are also more sensitive to extreme sea weather that generates high waves. This will be exacerbated if the communities are also from low-income groups.

Adaptive capabilities. Based on the study, agricultural communities have little capacity to mitigate or adapt to climate anomalies that might cause crop failures. However, they have developed institutional and technical capacity to prevent elephants from entering their farmland. This capability is accompanied by facilitation from the local government, particularly from Way Kambas National Parks. This capability also varied from village to village. For instance, at Taman Fajar, a barrier has been built to separate the Way Kambas National Park area from the agricultural fields. The barrier function is to prevent elephants from entering the field. On the other hand, the other villages, like Rantau Jaya Udik II, do not have this infrastructure.

For communities in coastal areas at Cabang, adaptation is simply going to Way Kambas National Park for fishing grounds during the east monsoon season. This season is typically characterised by strong winds and high waves that are dangerous for fishing activities. It should be noted that fishing inside the Way Kambas National Park area is illegal.

3.3.2. Loss of livelihood

Loss of livelihood represents a severe and long-term consequence of prolonged food insecurity. It encompasses the broader economic and social impacts that arise when communities cannot sustain their means of earning a living.

Risk exposure. The risk exposure for loss of livelihood is intricately linked to the same climate and environmental factors that drive food insecurity. In Lampung, persistent crop failures, extreme weather events, and conflicts with wildlife threaten food security and jeopardize the agricultural and fishing activities that form the backbone of local livelihoods. Coastal communities face heightened exposure to changing ocean conditions, including higher wave heights and extreme weather, which can disrupt fishing activities for extended periods.

Sensitivity. Communities already struggling with food insecurity are particularly sensitive to further economic disruptions. In Lampung, agricultural communities are susceptible to prolonged periods of crop failure, as their income and food supply are directly dependent on successful harvests. Similarly, fishing communities are vulnerable to adverse sea conditions, which can prevent them from fishing, thus eliminating their primary source of income. Low-income groups are doubly burdened as they lack the financial buffers to withstand prolonged disruptions.

Adaptive capabilities. The adaptive capabilities of these communities are limited by their existing vulnerabilities. While somewhat adept at mitigating wildlife conflicts with support from local institutions, agricultural communities often lack the resources to diversify their crops or invest in more resilient agricultural practices. Coastal communities, constrained by legal and safety concerns, cannot quickly shift to alternative fishing grounds or methods. The illegal status of fishing in protected areas like Way Kambas National Park underscores the limited and precarious nature of their adaptive strategies.

3.3.3. Increased heat-related illnesses and water-borne diseases

Climate change leads to higher temperatures and more extreme weather patterns, which can significantly impact public health.

Risk exposure. Increased temperatures directly expose communities to heat-related illnesses such as heat stroke, dehydration, and exhaustion. Furthermore, higher temperatures and altered precipitation patterns can enhance the breeding conditions for water-borne diseases like diarrhea and dengue fever, especially in areas with inadequate water and sanitation infrastructure. When tidal floods strike, the coastal area is more prone to water-borne diseases.

Sensitivity. Vulnerable groups, including the elderly, children, and individuals with pre-existing health conditions, are susceptible to heat-related illnesses. Coastal communities have observed an increase in mosquito presence during tidal floods, resulting in a rise in dengue cases. A person with dengue is very likely to require hospital treatment, which might burden the poor financially. Subsequently, poor communities with limited access to healthcare and clean water are more susceptible to outbreaks of water-borne diseases.

In addition, the agricultural workforce, often outdoors, is highly sensitive to heat stress. In Java Island, there is already a report of a farmer's death due to heatstroke (Mulato, 2023). Although no similar case has been found yet in Lampung, the increasing temperatures and prolonged exposure to heat present a growing risk to the health and productivity of farmers in the region (Talukder et al., 2021). Communities in Cabang are even more sensitive because of the area's lack of health facilities. Unlike the farmer communities in terrestrial areas, the Cabang communities have noticed the rising air temperature compared to several years ago. They expressed an increasing sense of discomfort due to the heat. This is probably due to the lack of shade from vegetation to protect them from direct exposure to the sun in their daily activities, whether at the settlement or when they go to the sea.

Adaptive capabilities. Communities rely on health facilities in the event of sickness due to exposure to tidal floods or high temperatures. Unfortunately, this is not the case for the communities at Cabang. The nearest health facility is relatively far away and can only be reached by sea police ship.

3.3.4. Displacement

Climate change-induced displacement refers to the forced movement of people due to environmental factors such as sea-level rise, extreme weather events, and resource scarcity.

Risk exposure. Coastal and low-lying areas are particularly exposed to displacement risks (Dong et al., 2024). Rising sea levels, severe droughts, and intense storms can render areas uninhabitable, forcing people to relocate. There is also a subsequent risk of coastal zone abrasion due to constant exposure to high-intensity waves and rising sea levels.

Sensitivity. Populations in impoverished regions with limited resources and fragile housing are highly sensitive to displacement. Losing homes, land, and livelihoods can significantly impact their ability to recover and adapt. These sensitivities are revealed as the communities in Sukorahayu and Margasari villages recalled historical extreme events. In 1997, during one of the worst events of El Nino that took a time span of approximately one year, the coastal area was heavily struck by high waves. These waves caused abrasion along the coastline that damaged houses and fishponds. Indeed, sea anomalies had been recorded during El Nino in 1997 particularly easterly winds along the southern Java-Sumatra (Sulaiman et al., 2023).

Adaptive capabilities. Very few adaptive capabilities have been shown, especially for communities at Cabang. The willingness to adapt, however, has been shown by communities in Sukorahayu and Margasari. They have previously established mangrove reforestation, although most of the efforts failed. The communities also partnered with institutions like Pertamina and Lampung Watershed Management Agency in the efforts.

3.3.5. Higher Cost of Living

Climate change impacts environmental and health conditions and significantly increases the cost of living for affected communities. This section examines the risk exposure, sensitivity, and adaptive capabilities associated with the higher cost of living due to climate change.

Risk exposure. The terrestrial areas are exposed to higher temperatures, leading to increased energy costs for cooling and more frequent damage to infrastructure, necessitating costly repairs and maintenance. The degradation of roads, buildings, and utilities due to heat stress further adds to living expenses.

Settlements in coastal areas are particularly vulnerable to rising sea levels, which induce tidal floods. These floods can damage homes and infrastructure, leading to increased costs for repairs and flood defences. Both terrestrial and coastal communities may face a lack of reliable water sources. This scarcity results in higher costs for purchasing water for drinking, agriculture, and other essential uses. As natural water sources become unreliable, the dependence on commercially supplied water increases, adding to household expenses.

Sensitivity. Farmers and agricultural workers are susceptible to the rising cost of living. Higher temperatures and water scarcity affect crop yields and livestock health, increasing the cost of production and reducing income. The need to invest in more resilient agricultural practices and technologies adds further financial strain (Alie et al., 2024). For instance, the increasing uncertainty of the weather patterns reportedly interrupts the scheduled practices to maintain the crops, such as pest eradication. Farmers in Taman Fajar village complained about the need to repeat pesticide spraying during the unexpected period of intense rains. More spraying means more expense in buying pesticides. Unfortunately, this added cost tends to be poorly compensated in the produce selling price. The farmers have little bargaining power to negotiate the appropriate selling price at the farmer level.

Families with limited financial resources are more vulnerable to the rising cost of living. They often spend much of their income on basic necessities, leaving little room for additional expenses. The increased energy, water, and food costs can push these communities deeper into poverty.

Communities living in coastal areas are sensitive to the economic impacts of rising sea levels and tidal flooding (N'Souvi et al., 2024). The costs associated with flood damage repairs, relocation, and preventive measures can be overwhelming, especially for those with limited financial resources. Particularly for communities at Cabang, the sensitivity is even getting more heightened. The cost of living in this area is already high due to difficult access and limited modes of transport. On top of that, the communities are already facing water scarcity. They have to spend significant amounts of money to buy bottled water for drinking. Bottled water and other goods are shipped from the sub-district central area, which takes a six-hour boat trip. The community must also spend significant money digging artesian wells for other needs like sanitary practices (bathing, wastewater, washing, laundry, etc.). Even more concerning, climate change is deemed to be one of the factors contributing to the depletion of global fish stock (Free et al., 2019). Worsening climate change means more difficulties for fishermen, for they have to go further out to sea, increasing the cost of fuel and boat maintenance (The Jakarta Post, 2022). Also, similar to farmers, fishermen do not have the bargaining power to decide the price point of their catch (Nuraini et al., 2024). So, they would be the party that bears the most economic burden of depleting fish stock.

Adaptive capabilities. Communities in terrestrial or coastal areas exhibit little adaptive capability to face rising living costs, particularly those whose livelihoods depend on agriculture and fishing. This is mostly because they do not have the resources to change their means of livelihood. In addition, their scope of skills and knowledge is inadequate for developing adaptation strategies, particularly to tackle the shifting pattern of wet and dry seasons.

3.3.6. More frequent and intensity of forest fire

This section examines the risk exposure, sensitivity, and adaptive capabilities associated with more frequent and intense forest fires due to climate change. The state of forest fire is a pre-existing condition in Lampung that tends to occur in the dry season. Of course, it should be noted that the dry season is not the sole factor of forest fires. As mentioned before, human activities, particularly poaching, are the main factor contributing to forest fires.

Risk exposure. Buffering villages that are in close proximity to Way Kambas National Park are more exposed to forest fires and their impacts. In the study, this is best represented by Rantau Jaya Udik II. The village is bordered by the area with the landscape of regularly flooded shrub-covered areas. In the long dry season, this landscape tends to turn into barren shrubbed land. With this landscape, this area is surely more prone to forest fires during this time. Sukorahayu and Margasari village's forest fires reportedly occur almost annually during the dry season, as reported by the communities. Coastal areas, in general, are less exposed to forest fires.

Sensitivity. Because of their proximity, the communities of Rantau Jaya Udik II are more sensitive to the impact of forest fires. The impact has reportedly been a disturbance from the resulting smoke and respiratory illness.

Adaptive capabilities. In this study, some villages have developed institutional capacities, although they are still very limited in technical skills and equipment. For instance, Sukorahayu and Rantau Jaya Udik II have established an organization called Masyarakat Peduli Api (Community for Fire Awareness) that has tasks assisting the firemen in extinguishing the fire and communal fire surveillance. They utilize the available tools, not specialized equipment, for fire extinguishment. For example, in Taman Fajar village, the community utilizes pest sprayer equipment.

4. Conclusion

Climate vulnerability of the local communities in Lampung is unique to the specific condition of the Lampung climate. As mentioned above, the Lampung climate is defined by less frequent extreme rains compared with other regions in Indonesia. Yet historical data (2004 – 2024) shows a steady increase, particularly for maximum temperatures, with a shift from 31.5°C to 32.5°C post-2014. Furthermore, the climate modelling from BMKG Indonesia predicts that from 2020 to 2049, Lampung will face rising temperatures, shifting wet seasons (in terms of length and timing), and increased extreme weather events.

Based on the current and future projection states, the communities' climatic vulnerability is mapped using the DPSIR framework. The societal impacts then expanded into three defining aspects: risk exposure, sensitivity, and adaptive capabilities. The mapping reveals that inland and coastal communities differ regarding these aspects. When it comes to exposure, inland agricultural communities face risks from drought, soil degradation, and unpredictable rainfall. Meanwhile, coastal communities are affected by rising temperatures, rising sea levels, tidal floods, coastal erosion, and the depletion of fish stocks. The sensitivity is heightened by means of livelihood, socioeconomic status, and access to healthcare. Farmers risk crop failure and higher maintenance costs, whereas fishermen must travel further offshore, increasing fuel expenses. Extreme weather events further disrupt coastal livelihoods. Marginalized groups—including the poor and elderly—face compounded risks due to limited healthcare access and displacement threats, with the most vulnerable being the coastal communities of Cabang Resort.

Furthermore, when it comes to adaptive capabilities, both terrestrial and coastal communities in Lampung have very limited capacities to anticipate most of the climate change impacts mapped in this study. Yet some villages have developed institutional capacities, although with limited technical skills and equipment. The least adaptive capabilities have been shown by the coastal communities at Cabang Resort. Strengthening climate resilience will require targeted interventions (Stacey et al., 2021) that include improvement of infrastructures, access to healthcare and the development of disaster readiness programs. In addition, it should be noted that these findings are intended to encourage policy interventions and service improvements, not to blame the communities, even though some parts of their activities are illegal.

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