

Climate Change, Food System Transformation, and Food Vulnerability of the Suku Anak Dalam in Bukit Duabelas National Park, Jambi Province

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ABSTRACT

Food is a general strategic issue that is directly related to human survival, including for the Suku Anak Dalam (SAD). Indonesia has 2,449 indigenous communities with more than 40 million people, most of whom depend on natural resources to meet their livelihoods. Studies show that indigenous peoples in various parts of the world face great pressures due to the impact of climate change on the environment, livelihoods, and biodiversity. This study aims to analyze SAD's perception of climate change and the transformation of their food systems in the context of Climate Change Impacts. The research uses a mixed method design with a dominant qualitative approach and quantitative data support. The results showed that 94% of respondents were aware of climate change, with the main causes being deforestation, the expansion of the palm oil industry, and intensive agriculture. The most felt impacts include rising temperatures, droughts, decreased water availability, and ecosystem disruptions. SAD food systems have undergone a shift from forest-based subsistence patterns to a mixed (hybrid) food model that is increasingly market-dependent. Despite this, they still retain ecological knowledge and customary law as the basis for adaptation. The integration of local wisdom with environmentally friendly agricultural innovations and policy support is needed to strengthen indigenous peoples' food adaptation and self-sufficiency amid the threat of climate change.

Keywords: climate change, food, local wisdom, transformation, Suku Anak Dalam

INTRODUCTION

Climate change is a global issue that has become a priority of the United Nations Sustainable Development Agenda (SDGs) through the 13th Goal on *Climate Action*. Indonesia affirms this commitment in Law Number 59 of 2024 concerning the National Long-Term Development Plan (RPJPN), which places the handling of the Impact of Extreme Climate Change (DPIE) as an integral part of the sustainable development and food security strategy. This is important because DPIE has been shown to increase risks in the agricultural sector, trigger a decline in productivity, and threaten national food sovereignty (Arias et al., 2023).

Rising global temperatures, increasing flood and drought intensity, and climate uncertainty have a direct impact on food security, especially for vulnerable groups such as indigenous peoples who are highly dependent on natural resources (Arias et al., 2023; WHO, 2021). It is estimated that there are around 370 million indigenous people in the world who are directly affected by climate change, especially those living with traditional forest-based food systems. Studies in Africa and Latin America show that indigenous peoples are the most vulnerable groups to DPIE due to historical exclusion and limited access to adaptive policies and technologies (Leal Filho et al., 2021).

In Indonesia, there are more than 2,400 indigenous communities with more than 40 million members (Redaksi, 2025). One of them is the Suku Anak Dalam (SAD) Indigenous Community which has long settled and depends on its source of livelihood from the Bukit Duabelas National Park (TNBD) area, Jambi Province. These communities face serious pressures due to forest degradation, narrowed living spaces, and reduced natural food sources. Recent studies on the SAD Community in TNBD Jambi Province revealed that SAD is still faced with the chronic problem of poverty and insufficient food and

nutrition vulnerability; they still highly rely on extractive activities such as hunting, gathering, and traditional agriculture (Muchlis et al., 2025). Concurrently, changes in the production system encourage profound transformations in the structure of land tenure, livelihood patterns, and cultural values of indigenous communities. The integration of indigenous peoples into modern commodity supply chains creates new pressures, especially for groups with limited resources who are ultimately only able to survive (Pandelaki et al., 2025). This condition results in a decrease in food diversity and a weakening of their food security over time.

Conventionally, the indicators used in measuring the impact of Climate Change and Food System Transformation have focused heavily on practical and technical metrics. These include detailed land management, protection of local varieties, local innovation systems, efficiency, sustainable settlements, social safety nets, maintaining land functions, physical modification of the environment, risk mapping, temporary relocation, allocation of joint funds, development of protection schemes, disaster risk management, securing farming assets, diversification, and protection of rights (Colvin et al., 2014; Farooq et al., 2019; Wilson, 2001). However, existing frameworks often treat these indicators as isolated technical responses to environmental shifts. While these studies capture the structural symptoms of food insecurity—such as shrinking forest areas due to population growth, land degradation, and depletion of food stocks (Muchlis et al., 2025) they frequently overlook how top-down structural governance and policy constraints limit the community's capacity to adapt. In the context of the SAD community, although they possess rich local knowledge and adaptive social systems, their capacity to mitigate climate impacts is increasingly bottlenecked by external pressures like changes in forest cover and plantation expansion, leaving a significant analytical gap regarding how macro-level policies actively shape localized socio-ecological vulnerabilities.

To address this gap and analyze the structural vulnerability of the SAD community, this study employs the Pressure and Release (PAR) Model developed by Wisner, Blaikie, Cannon, and Davis (2004). The PAR model posits that a disaster occurs at the intersection of two opposing forces: the processes generating vulnerability and the physical exposure to a hazard. In this context, the vulnerability is not merely a result of climate change as a natural hazard, but is rooted in a 'policy disaster'—specifically, the exclusionary conservation policies and the aggressive expansion of monoculture plantations. These policies act as dynamic pressures that transform long-standing traditional land-use systems into unsafe conditions, characterized by market dependency and a decline in food diversity. Consequently, when the community is exposed to climate-related hazards, such as prolonged droughts or erratic rainfall, their inherent resilience is 'squeezed,' leading to a state of structural food insecurity. To complement this, the Community Resilience Theory developed by Norris et al., 2008 is integrated to understand resilience as a process connecting adaptive capacities economic development, social capital, information systems, and community competencies with the ability to adapt positively post crisis. In a 'policy disaster' scenario, the weakening of these capacities directly escalates the community's vulnerability to rigid, non-responsive external regulations.

By synthesizing these frameworks, this research enriches climate change impact indicators, which previously focused on physical dimensions like extreme rainfall or drought, by shifting the paradigm toward socio-ecological, structural, and highly localized community-based indicators. Integrating the concept of 'policy disaster' and resilience theory, this study incorporates a new set of indicators. These range from structural aspects such as exclusion caused by restrictive conservation policies and monoculture expansion to indigenous vulnerabilities stemming from spatial squeeze, market dependence, and the loss of natural food diversity. Additionally, the baseline for adaptive capacity is broadened to include cultural values as social capital and the efficacy of traditional knowledge in climate mitigation. Thus, climate impact assessments move beyond macro-level metrics like decreased agricultural yields, offering a nuanced view of how external and ecological pressures diminish food sovereignty, erode local wisdom, and induce structural food insecurity among indigenous communities in conservation zones.

Based on the aforementioned context, this study aims to examine how the SAD community perceives climate change phenomena and food system vulnerability within the Bukit Duabelas National Park. Furthermore, it investigates how the transformation of their food system serves as an adaptive response to ongoing socio-ecological pressures.

METHOD

This research is designed in a *mixed method*, with qualitative dominance and a little quantitative descriptive with a case study approach (Creswell, 2022; Miles et al., 2014).

The research was conducted as an in-depth case study limited by a specific time frame and activity, with comprehensive data collection using a variety of procedures within a predetermined period. The goal is to uncover patterns in group dynamics through an in-depth exploration of finite systems, such as activities, events, processes, and individuals—based on extensive data (Creswell, 2022).

The determination of the sample and participants used the nonprobability sampling method with a combination of purposive sampling and snowball sampling. The main participant was the head of the SAD family from 6 Temenggung groups in the Air Hitam District Area, Sarolangun Regency, Jambi Province who have an attachment to TNBD's forest resources. From the total number of SAD households, 35 respondents were selected for the household survey. In addition, there were 12 supporting informants consisting of Temenggung, Jenang, employees of the TNBD Center, village officials, and key figures from the SAD community.

Qualitative data collection was carried out through field observations, transects, in-depth interviews, and Focus Group Discussions (FGDs), supported by field notes, audio recordings, and documentation (photos and videos). Quantitative data is collected through household surveys that include the use, access, and relationship with forests, and natural resources. food security systems and local food self-sufficiency, their perceptions of climate change, and the impact of climate change on community food security.

The assessment was carried out in July-October 2025, in Lubuk Jering Village, Pematang Kabau and Bukit Suban, Air Hitam District, Sarolangun Regency, Jambi, in the SAD groups/groups of Temenggung Bebayang, Melayau Tua, Bepayung, Afrizal, Nangkus and Ngrip, who still maintain traditional values and have an attachment to forests in TNBD.

Data were analyzed using an integrated mixed-method approach. Quantitative data were processed through descriptive statistics (frequency distribution and percentages) to map the trends in community perceptions of climate change. The research data was analyzed using thematic analysis based on the model developed by Braun & Clarke (2006), as well as the qualitative analysis approach of Miles (2014a), which includes data condensation, data display, and conclusion drawing/verification. To ensure data validity, the researchers applied triangulation techniques. Source triangulation was conducted by comparing data from interviews, observations, and documents to ensure consistency of information (Patton, 2015). Furthermore, method triangulation was conducted by comparing interview results with field observation findings to enhance data validity. Member checking was also conducted by asking informants to review the interview summary to ensure accurate data interpretation, in accordance with the principles of qualitative data validity (Lincoln & Guba, 1985).

This study employed a mixed-methods integration by converging quantitative data from a survey of 35 SAD households, analyzed using descriptive statistics to map trends in climate perception and food security, with a simultaneous qualitative approach. The qualitative operational details were executed through observation, transects, in-depth interviews, and FGD with 12 key informants across six *Temenggung* groups within the TNBD conservation area. Qualitative data were analyzed using thematic analysis and the interactive model Miles (2014) The findings from both methods were subsequently fully integrated through triangulation and member checking, ensuring that the quantitative data obtained gained deep, contextual meaning from the socio-ecological realities of the SAD community on the ground.

RESULTS AND DISCUSSION

SAD Community Perception of Climate Change

Climate change has led to an increase in global temperatures and triggered various hydrometeorological disasters such as floods, droughts, and storms in various regions of the world. This phenomenon poses a serious threat to the global food system because it disrupts agricultural productivity, water availability, and the economic stability of rural communities. The impact is most pronounced by vulnerable groups, especially children and low-income communities, who face an increased risk of malnutrition and food insecurity (Arias et al., 2023; WHO, 2021).

The impact of Climate Change is not only felt by urban or rural communities that depend on modern agriculture, but also by indigenous communities in rural areas whose livelihoods are still highly dependent on natural resources. Indigenous communities that rely on traditional practices such as hunting, gathering, and relocating farming are now increasingly vulnerable due to environmental degradation and changes in natural ecosystems.

SAD in Jambi Province is one of the real examples of indigenous communities facing pressure due to climate change and environmental transformation. Their dependence on forests as a source of food, water, and livelihood is now increasingly threatened by shrinking forest areas, land degradation, and declining biodiversity and food sources around Bukit Duabelas National Park (TNBD) (Muchlis et al., 2025). This condition makes the SAD community one of the most vulnerable socio-ecological groups to the impact of climate change in Indonesia.

The SAD community in the TNBD area of Jambi Province is an affected community that also feels the existence of climate change. The change they feel is the difference between the living conditions in the past and the current conditions. Based on the interview results, most respondents (94 percent) felt that there was climate change in their local area, and only a small percentage (6 percent) of the other respondents answered that there was no difference between the past and the current conditions.

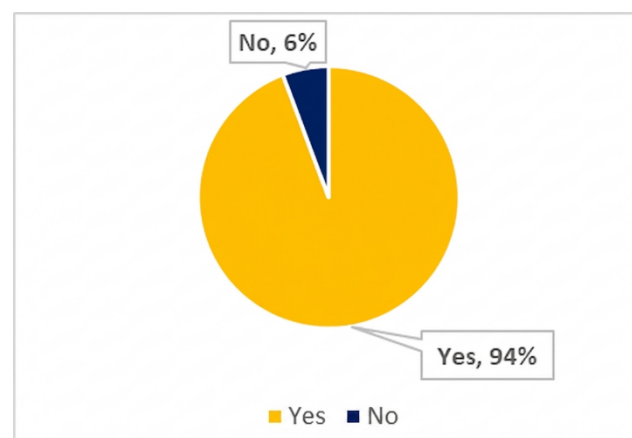


Figure 1. A diagram of the SAD community's views on climate change. Study results (2025).

The most widely felt forms of climate change include shifting seasonal patterns, increasing air temperatures (becoming hotter), extreme weather (floods and droughts), ecosystem disturbances (species extinction), reduced clean water sources (threats to water availability), and reduced local food sources (threats to food availability). This phenomenon is in line with the concept of global climate change which is influenced by an increase in *greenhouse gases* that disrupt the balance of the earth's climate system, causing regional weather and climate anomalies (Arias et al., 2023).

Climate change with increasingly uncertain weather conditions also affects the food availability of the SAD community. The reduced number of flowers in the forest not only eliminates the source of honey, but also leads to a reduction in the fruit season. In the past, the SAD community always celebrated the arrival of the fruit season, but in recent years such events have become less frequent. Although there are still trees that bear fruit, the results are not as dense as they used to be.

The condition of the river in their area continues to decline. The water discharge is getting smaller and the depth of the river is drastically reduced, causing fish habitats to be disturbed and fish populations to decline. As a result, fishing activities that used to be a daily source of food are now increasingly rare.

These changes to forest and river ecosystems show that the impact of climate change is not only felt through physical changes in the environment, but also threatens the sustainability of natural food sources that have been the main support for the lives of the SAD community. The *social-ecological system* (SES) resilience theory asserts that the dependence of indigenous communities such as SAD communities on natural resources is highly vulnerable to environmental changes, including changes in water availability and natural food sources that sustain their livelihoods (Folke et al., 2005).

Uncertainty over rainfall intensity and distribution also disrupts the availability of water sources vital for domestic needs and agricultural irrigation. This corroborates the findings of studies on the impact of

climate change on the hydrological cycle, which show an increase in the frequency and intensity of droughts and floods in many tropical and subtropical regions (Trenberth et al., 2014). The implication is a decrease in the productivity of local ecosystems and the depletion of the abundance of natural food sources, such as wild plants and freshwater fish, which have been an important part of the consumption patterns of the SAD community.

Causes of Climate Change

The survey results show that the level of understanding of the SAD community regarding the causes of climate change varies quite a bit. In general, they associate climate change with various human activities that have a direct impact on forest ecosystems and the surrounding environment. Based on the results of the field survey, most of the respondents assessed that deforestation, intensive agriculture, especially the expansion of oil palm plantations, and the activities of the palm oil processing industry (MCI) were the dominant factors causing climate change in their regions. In addition, the burning of fossil fuels, motor vehicle emissions, and forest fires are also considered to worsen environmental conditions.

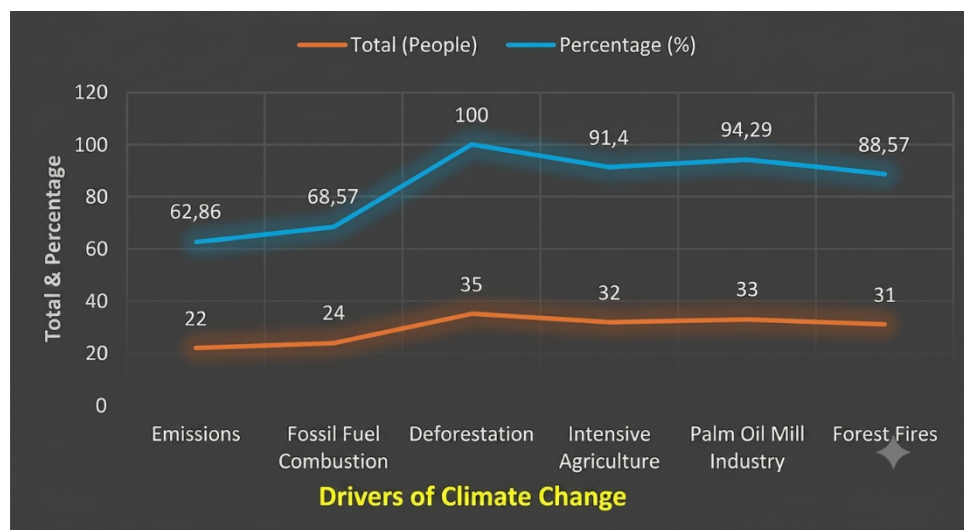


Figure 2. Respondents' Opinions on the Factors Causing Climate Change.

Source: Research Processing Data, Year 2025.

Figure 2 presents the SAD community's perception of the various factors causing climate change. The data showed that deforestation was the most dominant factor recognized as the cause of climate change, with all respondents (100%) stating that these activities contribute negatively to climate change in their region. These findings confirm that deforestation is seen as a major threat to the degradation of local ecosystems.

In addition to deforestation, the activities of the palm oil processing industry (PKS) were also considered to be very influential, namely 94.29%, intensive agriculture, especially the expansion of oil palm plantations (91.40%) of respondents which reflected the SAD community's concern about the massive land use change that has occurred in recent decades.

The next factor is forest fires, also considered an important cause of climate change (88.57%). Meanwhile, the burning of fossil fuels was acknowledged to be influential by 68.57% of respondents and the emission of motor vehicles and other emissions-producing activities was shown by 62.86% of respondents.

Overall, the above data show that the SAD community has a high level of awareness of the role of human activities in triggering climate change. The greatest emphasis is seen on activities related to forest conversion and the expansion of the palm oil industry, which communities see as the most damaging and most obvious factors affecting their environment.

The above data also shows that despite their relatively low level of formal education, the majority of community members still have a fairly good understanding of the sources of climate change. This is inseparable from their access to digital information through mobile phone devices. This trend is in line

with the findings of who stated that digital media plays a significant role in improving the ecological literacy of indigenous peoples with limited access to formal education.

The SAD community's perception of the causes of climate change is also in line with which asserts that deforestation, intensive agriculture, and forest fires are the main sources of increased CO₂ emissions as well as triggers of local climate instability). The assessment that the expansion of oil palm plantations is the most influential factor is inseparable from the changes they have experienced since the 1990s, when secondary forests around the TNBD area were transformed into transmigration areas and oil palm plantations. These changes in vegetation cover reduce carbon sequestration capacity, increase local temperatures, and change the microclimate patterns in the region.

On the other hand, the increasing use of motor vehicles and economic activities based on the palm oil processing industry have also formed a new awareness in the SAD community regarding the contribution of exhaust gas emissions and the burning of fossil fuels to global warming. This shift in understanding illustrates the shift in ecological perceptions of the SAD community, from a traditional view that is entirely grounded in the natural cycle to a more modern, critical, and based perspective on the causal understanding between human activities and climate change.

Impact of Climate Change on SAD Communities

Most respondents identified rising air temperatures and declining water availability as the most obvious impacts of climate change. When the forest cover is still dense, the temperature feels cooler and the river water is abundant. Now, temperatures are rising, water discharge is decreasing, and flooding is easier to occur even if rainfall is not high.

Table 2. Impact of Climate Change on SAD Communities (2025)

Yes	Impact	Number (people)	Percentage (%)
1	Temperature Rise	35	100.00
2	Flood	32	91.43
3	Drought	34	97.14
4	Ecosystem Disruption	33	94.29
5	Water Availability Disruption	35	100.00

Source: Research Processing Data, Year 2025.

The table above shows that the SAD community's perception of the impact of climate change is that they feel directly. The data showed that rising temperatures and disruptions in water availability were the most significant impacts experienced by all respondents (100%,). These results confirm that temperature changes and decreased access to clean water are the main problems that affect community activities and survival. SAD

In addition, the impact of drought was also felt by most respondents, namely 97.14%. This impact is in line with the reduction of river discharge and the shrinking of surface water sources which have been the source of meeting household water needs and subsistence activities of the SAD community. The next impact is ecosystem disturbance, which is reflected in changes in animal behavior, a decrease in non-timber forest yields, and vegetation damage, felt by 94.29% of respondents. This condition indicates increasing ecological pressures due to climate change and environmental degradation occurring in the area around their settlements. Meanwhile, flooding was another significant impact and was felt by 91.43%. Although not experienced by all respondents, the increasing frequency of floods shows instability in rainfall patterns and reduced soil absorption capacity due to changes in land cover. The change and length of the dry season and rainy season are suspected by the SAD community to have caused drought conditions and flood situations in their area. In the past, when rainfall was relatively high, there was no flooding situation in the SAD community area, but today, if it rains, even with relatively low rainfall, the water of the small rivers around their neighborhood will overflow quickly. Likewise with drought conditions, if the dry season has arrived, then in a short time, the SAD community will feel a shortage of water, due to the limited capacity of the soil body to maintain water as a water reserve in the soil.

Climate change also has an impact on forest ecosystems. Game animals such as deer, pangolins, and wild boars are increasingly difficult to find, so natural sources of protein are reduced. SAD communities have also begun to abandon field food crops such as cassava and bananas, switching to commercial crops such as oil palm and rubber. Changes in rainfall patterns have a direct impact on the local

economy. Long dry seasons lower rubber production, while floods disrupt access to land. The SAD community understands that the destruction of nature is a direct result of human activities, and therefore maintains local wisdom such as the preservation of *the continents*, *peranakon*, *ridges*, and *subons* as ecological zones that should not be disturbed.

These findings are in line with research by Garai et al. (2022) in Bangladesh, which suggests that indigenous peoples have a good understanding of climate change. These results also confirm the findings of (Surmaini & Faqih, 2016), that poor farmers are the most vulnerable group to extreme weather such as droughts and floods.

Farming communities generally rely on networks of adaptive capacity, particularly social capital and local resource management, to maintain food barn institutions (Mariyani et al., 2019). However, in extreme climate scenarios, resilience based on livelihood systems that are continuously stressed and dependent on natural resources remains fragile and limited (Subair et al., 2015). To improve the food security and livelihood resilience of farming households, increasing public physical capital is necessary (Putri & Pandjaitan, 2016).

The results of interviews with respondents also show that climate change has a real impact on the daily life of the Orang Dalam (SAD) community. These impacts include: (1) a decrease in livelihoods due to the reduction of game animals such as snakes, monitor lizards, and wild boars; (2) the shift of crop types from farm foods such as cassava, bananas, and sweet potatoes to plantation crops such as oil palm; (3) changes in rainfall patterns that cause flooding even though it rains in a short period of time; and (4) a decrease in rubber production during the long dry season which has an impact on the local economy.

The SAD community believes that climate change is mainly caused by human activities that damage the balance of nature. They have an ecological view that the relationship between humans and nature is reciprocal, so environmental damage will have a direct effect on human life. As a form of adaptation and preservation, they still maintain local wisdom such as the protection of *the benuaron* area (fruit tree area), *peranakon* (birthing place), *ridge* (steep area), and *subon* (source of animal drinking water) as sacred areas that should not be disturbed.

The area that is still guarded by the SAD community shows a relatively stable ecological condition compared to the surrounding area which has been dominated by oil palm plantations. The community also has the traditional knowledge to recognize the changing seasons based on natural signs such as cold morning temperatures, the reddish color of the sun, and the sound of the *owl* that marks the turn of the seasons.

These findings show that SAD communities have an ecological understanding and awareness of climate change, both regarding its causes and impacts on their lives. These results are in line with the research of Garai et al. (2022a) which found that indigenous peoples in Bangladesh have a good perception of climate change; the findings also confirm that poor and smallholder groups are the most vulnerable to extreme climate impacts such as drought and floods. Therefore, increasing the adaptation capacity and income of indigenous peoples is important to strengthen their resilience to ongoing climate change.

Furthermore, the shift in livelihood strategies observed in this study reflects a broader pattern of socio-ecological adaptation. As highlighted by Rahmawati & Dharmawan, (2012) in *Sodality*, climate change forces rural and indigenous communities to diversify their livelihoods as a survival mechanism against production failures in their primary ecological sectors.

Transformation and Vulnerability of SAD Food Due to Climate Change

The food system in the SAD Indigenous Community is traditionally characterized by a subsistence pattern, namely hunting, concocting and farming of shifting fields that are in harmony with the TNBD forest ecosystem. This system not only guarantees food security, but also becomes part of the cultural identity and ecological wisdom of the community (Zuhud et al., 1998).

However, the food system is now undergoing a transformation towards a vulnerable hybrid system. The shift from forest-based subsistence patterns to market dependence has changed the structure of production, consumption patterns, and people's livelihoods. This dependence increases the risk of vulnerability to Extreme Climate Change Impacts such as droughts and floods (Arias et al., 2023). Data shows a shift in local staple food sources such as cassava and banar yam. from the forest to the purchase of food in the market, such as rice and instant noodles. This homogenization of food sources reduces food diversity and increases dependence on a single caloric source, making communities particularly vulnerable when rice supply is disrupted or prices rise.

To meet market-based food needs, the SAD community turned to commercial livelihoods such as plantation cultivation such as rubber, oil palm, and areca nut. The shift in the function of *Tano Pusako* from subsistence food land to commodity land strengthens economic dependence on market prices. Fluctuations in the price of rubber and palm oil commodities directly reduce people's purchasing power for staple foods, especially when crop yields decline due to extreme climate phenomena.

Forests that previously functioned as a *buffer for* food security are now losing their carrying capacity. The decline in the availability of forest food sources such as tubers, deer, and mouse-deer is caused by land degradation and climate change that damages natural habitats. As a result, most of the respondents have experienced food difficulties in the past year. These conditions reflect that the transformation of the SAD food system has created structural vulnerabilities due to a combination of market pressures, environmental degradation, and climate change.

The transformation of the SAD food system from forest-based to market-dependent is closely linked to their diminishing access to forest resources. This is consistent with Sunito (2021), who argued that for SAD households, food security is no longer determined solely by forest availability but is increasingly dictated by their ability to participate in the market economy due to land-use changes.

The Food Diversity Crisis

Local food sovereignty The SAD Community rests on two main pillars, namely food *diversity* sourced from forests and fields, and food *self-sufficiency* achieved through the management of customary territories (*Tano Pusako*). However, the results of the study show that these two pillars are now experiencing a structural crisis due to environmental pressures and economic shifts. The diversity of SAD foods is at a critical point. Most respondents assessed the availability of food from forests such as tubers (sweet potatoes, banar yams) and animal proteins (pigs, deer, mouse-deer, fish) in the category of "lacking" or "sufficient". Only a small percentage state that it is "plentiful". This condition indicates two main things:

1. Habitat degradation due to the expansion of economic activities around the Bukit Duabelas National Park (TNBD) area,
2. The direct impact of climate change such as drought and floods that reduce the productivity of forest ecosystems.

The decline in the diversity of wild food sources substantially weakens the community's nutritional base and food security. Wild foods rich in micronutrients and protein play an important role as *buffers* when field harvests fail. Today, SAD food consumption is increasingly homogeneous and depends on one source of carbohydrates, namely rice. Consumption frequency data shows that rice is consumed two to three times a day, while the consumption of forest tubers decreases dramatically. This homogenization of food consumption leads to a loss of nutritional quality and dependence on external supplies. SAD's food self-sufficiency is now shifting from subsistence production to market dependence. People buy rice and instant noodles as the main food source, replacing local production. This shift is in line with the change in livelihoods from food agriculture to non-food commodities such as rubber, palm oil, and areca nut. However, the economy's dependence on these commodities increases the risk of vulnerability to price fluctuations and crop yields. The prevalence of SAD food is also triggered by two factors:

1. Price risk, namely the decline in rubber prices, is the main commodity that reduces the purchasing power of staple foods.
2. Production risk, namely a decrease in crop yields due to the impact of Extreme Climate Change such as long droughts.

These two factors have caused SAD to experience food difficulties "frequently" to "very often" in the past 12 months. In addition to economic factors, institutional restrictions in the management of TNBD have also weakened food self-sufficiency. While SAD understands the importance of forest protection, restrictions on hunting and concoction activities reduce access to traditional food sources. This erodes the function of *Tapak Komunal* as a reserve food barn and narrows the community's adaptation space to the food crisis. Thus, the threat to SAD's food sovereignty is twofold, namely economic pressure from market volatility and institutional pressure from restrictions on access to natural resources. This is in line with the research results of Turasih & Kolopaking (2016) which stated that the wider the land controlled by farming households, the more access to capital and their vulnerability to climate change can increase or decrease, depending on their ability to manage resources and the adaptation strategies they have. Future adaptation efforts need to be directed at restoring the ecological base of customary

foods and strengthening socio-economic protection mechanisms so that the SAD community can be more resilient to market risks and climate change.

SAD's Food Security to the Impact of Extreme Climate Change

The food security of the SAD Indigenous Communities faces existential threats due to the impact of Extreme Climate Change. These threats have transitioned from theoretical risks to empirical realities, eroding the traditional subsistence foundations that have underpinned community life (Arias et al., 2023; James & James, 2010). The SAD's response to these changes shows a combination of local wisdom and the need for more modern technical-structural adaptation.

The majority of respondents stated that they experienced seasonal changes, increased temperatures, and unpredictable rainfall, which had a direct impact on food productivity and water resources. They also identified three key impacts of DPIE, namely:

1. Extreme weather (floods and droughts) that disrupt the plant-harvest cycle,
2. Ecosystem disturbances that reduce the availability of forest food such as game animals and wild tubers,
3. Threats to food and water security, which are explicitly linked to their survival.

Prolonged drought leads to a decrease in field yields (*behumo*) and reduced water resources, weakening household food stability. This condition is exacerbated by market dependence, where fluctuations in the price of non-food commodities (such as rubber and palm oil) directly affect people's purchasing power for staples. A large number of households reported experiencing "frequent" to "very frequent" food difficulties in the past 12 months, evidence that traditional buffering strategies such as forest food reserves are no longer sufficient. In the face of these conditions, the SAD community developed a variety of pragmatic adaptation strategies, including: (a) Rapid technical adaptation, such as planting fast-harvesting varieties to adjust to the uncertainty of the seasons; (b) Safeguarding food assets, by storing crops and purchasing food for reserves; and (c) The use of social capital, through cooperation between community members as a mechanism for mutual cooperation to face crises. These findings are in line with the results of studies in Bangladesh and the Philippines that show that indigenous peoples are leveraging social networks and traditional practices to mitigate the impact of climate change on food security (Garai et al., 2022).

The ecological ethics of the SAD, which is reflected in the belief that "*humans are not the rulers of nature*", serves as a moral and ecological foundation for resource conservation. Customary practices such as *Hompongan* (collective rituals), prohibitions on damaging *the benuaron* and *ridge areas*, and the application of *customary law* in resource management play a role as an instrument of ecological mitigation (Zuhud et al., 1998). Thus, local wisdom of SAD not only has cultural value, but is also a form of ecosystem-based mitigation that is relevant to the modern context of climate adaptation.

However, local wisdom alone is not enough to deal with the increasing intensity and variability of DPIE. Therefore, collaborative strategies that integrate traditional knowledge with modern adaptive technologies, such as the use of climate-resistant varieties and efficient irrigation systems are needed. External assistance and intervention programs that have been received by the community need to be directed to contextual technology transfer, in line with TNBD's customary and ecological values. This integration will strengthen the food resilience of communities while preserving their ecological knowledge as part of sustainable adaptation.

Theoretically, this study advances the discourse on resilience by demonstrating how collaborative strategies can dismantle and eliminate the 'policy disaster' structurally embedded within conventional, top-down conservation paradigms. By shifting the governance framework from an exclusive-restrictive approach toward a localized co-management model, this integration bridges the structural gap between state conservation mandates and indigenous survival. Contextual technology transfer, when strictly aligned with TNBD's customary (*adat*) and ecological values, transforms external interventions which initially triggered a 'spatial squeeze' and socio-ecological alienation into instruments of empowerment. Consequently, this collaborative approach eliminates the 'policy disaster' by restoring the community's agency and sovereignty over their food systems. This theoretical integration not only strengthens the immediate food security of the SAD community but also preserves their foundational ecological knowledge, while offering a sustainable, rights-based climate adaptation model in conservation areas.

CONCLUSION

SAD indigenous communities are highly aware of climate change and its impact on their lives. They understand that deforestation, expansion of oil palm plantations, as well as industrial activities and the burning of fossil fuels are the main causes of climate change around Bukit Duabelas National Park (TNBD). The impact can be seen from rising temperatures, declining water availability, and declining biodiversity that disrupts their traditional food systems.

The transformation from forest-based subsistence food systems to market-based consumption patterns has reduced food diversity and increased vulnerability to price fluctuations and extreme climate. However, the SAD community still maintains local wisdom such as the preservation of *continents*, *ridges*, and *subons* as a form of ecological adaptation.

This study offers a novel contribution to the existing literature by explicitly integrating climate change issues with the structural transformation of indigenous food systems a nexus that has hitherto been under-explored in studies on the SAD community. By employing a socio-ecological vulnerability perspective, this research moves beyond conventional impact assessments, revealing that this shift does not merely represent a loss of traditions, but rather the emergence of a precarious 'hybrid food system' model, wherein the SAD community becomes increasingly ensnared in market dependency due to structural constraints.

To strengthen food security, an integrated adaptation strategy is needed that combines local wisdom with modern technology as well as policy support for ecosystem restoration and protection of indigenous territories.

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CRedit Contribution. **FM** Conceptualization, Formal Analysis, Writing – Original Draft. **EM** Methodology, Investigation, Data Curation. **ZF** Visualization, Writing – Review & Editing. **YM** Supervision, Administration, Validation

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