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Silent Crisis: How Climate Change Undermines Food Security and Drives Malnutrition in Papua's Indigenous Populations

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Abstract: This study examines the impact of climate change on malnutrition in the indigenous Asmat communities of As and Atat villages in Papua, Indonesia, employing a descriptive qualitative method with participatory observation and triangulation analysis. Despite their minimal contribution to climate change, these forest-dependent communities face significant challenges as altered weather patterns disrupt traditional food systems. The research reveals a direct correlation between global climate change and local food insecurity, manifested through changes in food-seeking seasons, natural food source scarcity, and disrupted consumption patterns. Key findings include changes in annual food-seeking cycles, increased rainfall (3500-4500 mm/year) causing prolonged flooding, and rising sea levels (peak 5.3 m) submerging cultivated land, collectively contributing to nutritional deficiencies and malnutrition. This study contributes to the growing literature on climate change impacts on indigenous health and food security, offering valuable insights for global policymakers and researchers addressing similar challenges.

Keywords: Climate Change Impact, Malnutrition, Indigenous Communities, Food Security, Environmental Adaptation.

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1. Introduction

The impact of climate change on indigenous communities has become a critical area of research in recent years, with studies exploring various aspects including economic losses (Ahmad Wani & Ariana, 2018; Avdeeva et al., 2017; Maryen et al., 2021; Tsosie, 2007), political implications, adaptation strategies, gender dynamics, and health outcomes (Ford, 2012; Ilham & Patmasari, 2022; Rohim et al., 2023; Ohoiwutun et al., 2023; Tripathi, 2024). However, there remains a significant gap in the literature regarding the specific impacts of climate change on indigenous public health, particularly concerning malnutrition (Ayeb-Karlsson et al., 2024). This study aims to address this gap by examining the relationship between climate change and malnutrition in the indigenous Asmat communities of Papua, Indonesia.

The Asmat people, particularly those in the As and Atat villages of the Pulau Tiga District, Asmat Regency, represent a unique case study in climate vulnerability. These communities, with populations of 451 and 605 respectively as of 2021 (BPS Asmat Regency, 2021), inhabit a region dominated by peat swamp and mangrove forests. Their traditional lifestyle is intricately linked to the natural environment, with livelihoods dependent on gathering forest products, fishing, and hunting. This close relationship with nature makes them particularly susceptible to environmental changes.

The Asmat region has faced significant challenges related to malnutrition, culminating in a major outbreak in late 2017 and early 2018. This event, first reported by national media (Kompas, 2018; Affan, 2018; Akbar, 2018; Janur, 2018), drew international attention to the health vulnerabilities of these indigenous communities. While various factors contribute to malnutrition in such settings, including poverty and limited healthcare access (Widjaja et al., 2018; Pamungkas, 2018), this study posits that climate change plays a crucial, yet often overlooked, role in exacerbating these issues.

Our research employs a multidisciplinary approach, drawing on concepts from anthropology, ecology, and climate science to examine the complex interplay between environmental changes and community health. By focusing on the As and Atat villages, we provide a detailed case study that illuminates broader issues facing indigenous communities globally in the context of climate change.

This paper aims to analyze the specific impacts of climate change on traditional food systems in the As and Atat communities, examine the relationship between these environmental changes and the prevalence of malnutrition, and explore the implications of these findings for policy development, health interventions, and environmental management strategies. By addressing these objectives, this study contributes to the growing body of literature on climate change impacts on indigenous communities, offering insights that may be applicable to similar contexts worldwide. Moreover, it emphasizes the importance of integrating indigenous perspectives and knowledge into climate change adaptation strategies and health interventions (Barpujari & Sarma, 2017).

2. Theoretical Overview of the Main Concepts

This theoretical framework provides a multi-faceted lens through which to analyze the complex interactions between climate change, indigenous food systems, and health outcomes in the As and Atat communities. It allows for a nuanced understanding of both the vulnerabilities and the potential resilience of these communities in the face of environmental changes. This study is anchored in a rich tapestry of theoretical frameworks that illuminate the complex relationships between indigenous communities, their environment, and the impacts of climate change. At the heart of our approach lies Julian Steward's (1955) concept of cultural ecology, which provides a lens through which to understand the As and Atat indigenous communities' adaptation to their forest environment. Cultural ecology posits that human communities develop specific cultural practices in response to their environmental conditions, a process Steward termed "sociocultural integration." This framework is particularly salient in our research context, as it helps elucidate how the As and Atat communities have traditionally interacted with their environment and how climate change may be disrupting these long-established patterns of adaptation.

Steward's approach emphasizes three key aspects in examining cultural ecology: the relationship between technology, resource exploitation, and the environment; patterns of community action in resource use; and the influence of value and belief systems on environmental interactions. These elements provide a structured way to analyze the As and Atat communities' responses to environmental changes, allowing us to consider both the technological and cultural dimensions of their adaptive strategies.

To fully contextualize the As and Atat communities within this framework, we draw upon various anthropological and legal perspectives on indigenous communities. Tee Haar's (1937) definition, as cited in Alting (2010), emphasizes historical continuity, territorial attachment, cultural autonomy, and community cohesion. This conceptualization is complemented by the Indonesian legal framework, outlined in the Minister of Home Affairs Regulation No. 52 of 2014, which provides specific indicators for recognizing indigenous communities. Additionally, Koentjaraningrat's (1990) cultural elements framework offers a comprehensive view of indigenous culture, categorizing it into seven interconnected systems. These perspectives collectively provide a nuanced understanding of the As and Atat communities' unique characteristics and rights within their broader sociopolitical context.

Our theoretical framework also incorporates the concept of ecosystem interdependence, recognizing humans as integral parts of their ecosystems. This perspective aligns with contemporary ecological thinking and is particularly relevant to indigenous communities like the As and Atat, whose lifeways are intimately connected to their natural environment. It emphasizes the mutual influence between human communities and their surrounding ecosystems, highlighting the critical importance of maintaining ecological balance for both human welfare and environmental sustainability. This concept is especially pertinent given the As and Atat communities' close reliance on forest resources, making them particularly vulnerable to ecological disruptions.

Finally, our research is informed by current understandings of climate change impacts on indigenous

communities, drawing on works such as Tauli-Corpuz et al. (2008) and Redvers et al. (2023). These studies highlight the disproportionate vulnerability of indigenous peoples to climate change impacts, despite their minimal contribution to global warming. They also emphasize the dual role of indigenous communities as both guardians of biodiversity and victims of climate change. In the context of the As and Atat communities. This framework helps us explore the specific threats to food security and health posed by climate-induced changes to traditional food systems and ecological knowledge (Idris et al., 2021; Issahaku et al., 2023; Maria Paula de Albuquerque, Paola Micheloni Elvira Ibelli, 2023; Tajidan et al., 2022).

3. Methodology

Research Design

This study employed a descriptive qualitative approach to examine the impact of climate change on malnutrition cases in the indigenous communities of As and Atat villages, Pulau Tiga District, Asmat Regency. The qualitative design was chosen to capture the complex interplay between climate change, traditional food systems, and health outcomes in these communities.

Study Area and Population

The research was conducted in As and Atat villages, located in the Pulau Tiga District of Asmat Regency, Papua, Indonesia. These villages were selected due to their recent history of malnutrition outbreaks and their vulnerability to climate change impacts. The study population consisted of indigenous Asmat people belonging to the Joerat Group.

Data Collection

This study employed a comprehensive mixed-methods approach to data collection, integrating both primary and secondary data sources. This methodological pluralism was designed to capture the multifaceted nature of climate change impacts on food security and nutrition in the As and Atat indigenous communities, ensuring a rich and nuanced understanding of the phenomena under investigation.

Central to our primary data collection was the use of participatory observation, a method deeply rooted in anthropological traditions (Spradley, 1980). Researchers immersed themselves in the daily lives of the As and Atat communities, meticulously documenting food practices, livelihood strategies, and environmental challenges. This ethnographic approach allowed for the capture of nuanced, contextual data that might be overlooked by more structured methods. It facilitated a deep understanding of the communities' lived experiences and their dynamic interactions with their changing environment, providing invaluable insights into the subtle ways climate change manifests in their daily lives.

To complement the observational data, a series of focus group discussions (FGDs) were conducted. These FGDs, guided by semi-structured protocols, served as forums for community members to collectively articulate their perceptions of seasonal changes, food availability fluctuations, and emerging health issues. The group dynamic inherent in FGDs fostered rich discussions, allowing for the emergence of shared narratives and the identification of areas of consensus and divergence within the community (Morgan, 1997). This method was particularly valuable in capturing the communal understanding of environmental changes and their impacts on traditional food systems.

In-depth interviews with key informants formed another crucial component of our data collection strategy. These interviews targeted a diverse range of stakeholders, including community leaders, health workers, and local government officials. The semi-structured nature of these interviews allowed for focused inquiry into specific issues while maintaining the flexibility to explore emerging themes (Kvale, 2007). This approach yielded detailed, expert perspectives on the intersections of climate change, food security, and community health, providing critical insights that informed our broader analysis.

To contextualize and corroborate the primary data, an extensive review of relevant documents was undertaken. This included the examination of health records, government reports, and previous academic studies pertinent to the region and the issues under investigation. This documentary analysis served

multiple purposes: it provided historical context, offered quantitative data to complement our qualitative findings, and helped identify trends and patterns over time that might not be apparent from short-term observations or interviews alone.

Data Analysis

The analytical approach employed in this study was designed to rigorously examine the complex interplay between climate change, food security, and malnutrition in the As and Atat indigenous communities. A multi-faceted methodology was utilized to ensure a comprehensive and nuanced interpretation of the collected data.

Central to our analytical framework was the application of thematic analysis, a method well-suited to identifying, analyzing, and reporting patterns within qualitative data (Braun & Clarke, 2006). This approach was particularly appropriate given the rich, contextual nature of the information gathered through interviews and focus group discussions (FGDs). The process began with the meticulous transcription of all verbal data, ensuring the capture of both linguistic and paralinguistic features that could provide additional layers of meaning. Subsequently, the transcripts were subjected to a systematic coding process. This involved a close reading of the data, with the researchers assigning codes to segments of text that represented key concepts or ideas relevant to the research questions. The coding process was iterative, allowing for the refinement and development of codes as the analysis progressed.

Following the initial coding, the researchers engaged in a process of theme development. This involved examining the codes for broader patterns of meaning that could illuminate the participants' experiences and perceptions of climate change impacts, shifts in food security, and the emergence of malnutrition issues. The themes were then reviewed and refined to ensure they accurately represented the data and addressed the research objectives. This process allowed for the identification of recurring narratives and shared experiences across the participant group, as well as the detection of any divergent or unique perspectives that could provide additional insights.

To enhance the robustness and credibility of the findings, a triangulation approach was employed (Denzin, 1978). This method involved cross-verifying data from multiple sources, including interviews, FGDs, observational field notes, and secondary data sources such as meteorological records and health statistics. The triangulation process served several critical functions. Firstly, it allowed for the corroboration of findings across different data sources, thereby increasing confidence in the validity of the results. Secondly, it provided a more comprehensive view of the phenomena under study by integrating perspectives from various stakeholders and data types. Finally, triangulation helped to identify any discrepancies or contradictions in the data, prompting further investigation and a more nuanced interpretation of the findings.

Ethical Considerations

The study adhered to ethical guidelines for research involving indigenous communities. Informed consent was obtained from all participants, and community protocols were respected throughout the research process. The study was approved by [FISIP ethics committee].

4. Discussion

As and Atat Indigenous Communities and Food Security

The communities of As and Atat villages are 100% Asmat Joerat Group indigenous people who are Catholic. Compared to various institutions in the village (Customary Institutions and Village Government), religious institutions (Catholic Church) have significant influence and roles in various areas of community life. This role and influence are seen in the presence of a Catholic priest specifically assigned to both villages and various health, education, and economic empowerment programs motored and facilitated by the Catholic church. There are four immigrant households, namely teachers who teach at YPPK As and Atat elementary schools.

The main livelihood of As and Atat communities is gathering or collecting forest products such as sago, fruits, shoots, animals, poultry, and various fish. In addition, they also learn to cultivate several types of plants in groves and in house yards. There are three types of food sources, namely (1) from forest products; (2) community cultivation results; (3) from outside / kiosks - shops. The source of food ingredients from cultivation and also sold by basic food supply kiosks in As - Atat in 2017 - 2018 was very limited and even unavailable. Data in table 5.3 shows that almost 90% of all food sources for As and Atat indigenous communities come from the forest.

In the subsistence economy of indigenous communities, forests have a central role in food security, such as meeting food needs, because subsistence communities still access food ingredients from the forest. This shows that food needs are centered on natural products. Thus, in the cultivation process, most people have not utilized yards or groves for food source cultivation to support household consumption. Efforts to fulfill needs and process food ingredients every day are mostly done by women (mothers and teenage girls) with a higher level of burden compared to men . The consumption pattern of As and Atat communities for three meals with local food sources is quite available such as sago, fish, shrimp, chili, and spices other than onions. Meanwhile, secondary food needs follow the pattern of the modern economy with market transactions that include coffee, tea, sugar, salt, MSG, cooking oil, onions, and rice. This fact is not something constant or stable because the shopping and consumption patterns with the above percentage are very determined by the availability of money. Based on our field observations, the nutritional adequacy rate from consumed food sources found that even if non-local food ingredients (rice, sugar, palm oil, etc.) were excluded, the Nutritional Adequacy Rate (AKG) in As and Atat Villages was 205% above the national standard, the Energy Adequacy Rate (AKE) was 96% above the national standard, the Protein Adequacy Rate (AKP) was 24% above the Fat Adequacy Rate (AKL) and 254% above the Carbohydrate Adequacy Rate (AKK).

Perception of Seasonal Changes in As - Atat Indigenous Communities

So far, there has been no study on malnutrition cases in Asmat, As and Atat villages in Pulau Tiga district linked to the impact of climate change. Looking at the cultural ecology of Asmat, especially in As and Atat Villages, it cannot be denied that global climate change has local impacts as shown in the average rainfall report for 1991 - 2020 published by the Meteorology, Climatology, and Geophysics Agency (BMKG) which shows that the average rainfall in the Papua region - especially the Asmat area is in the medium rainfall category, which is 200 - 300 mm/month and the high rainfall category, which is 300 - 400/month (Haryoko & Gunawan, 2021). Average monthly rainfall in the medium category occurs in May, June, August, September, and November. The high average monthly rainfall category occurs in January, February, March, July, October, and December (Haryoko & Gunawan, 2021).

In addition to rainfall data, in a time series (2015 - 2023), sea level rise on the southern coast of Papua, especially Merauke and surrounding areas, was found as illustrated in Table 5.6. The measure used is the highest sea level rise in one month, the duration of inundation, and the number of tidal days indicated by the date. From the available data, it was found that the highest sea level rise occurred in the range of 4.6 m in July to 5.3 m in March. It should be noted that from 2015 - 2022 the fluctuation of sea level rise in each month was relatively stable, but one surprising thing happened in 2023 in March where there was an increase to the level of 5.3 m. In general, sea level rise above 4.5 m for the Asmat area and especially As and Atat Villages becomes a serious problem because at this height, seawater has inundated and submerged all land and areas including food source plants. Another thing found was that the length of time of inundation when sea level rise at the highest point (water sitting) until the hour moves down/recedes needs a short time but there is also very slow (needs several hours stable before going down). It also needs to be calculated that the problem of sea level rise at the highest point occurs not only once or one day in a month but can occur consecutively for several days or several times in a month on different days/dates.

In addition to the above data, the As and Atat Communities in Focus Group Discussions and interviews recounted several facts related to the climate change phenomena they experienced. As a community living in the midst of the forest and depending on and following the rhythm of nature, they are very sensitive to changes occurring in nature and their living environment. Mr. Thomas - Chairman of the Church Council of

As and Atat Station said:

"the seasons are now chaotic, it should be the dry season, it has changed to the rainy season and big floods, the sea is also rising bigger and higher now, all plants are destroyed, the season for forest trees to bear fruit has also become rare".

Meanwhile, Mama Natalia - a health cadre from As village recounted: "certain months like from September to December and also January to February we experience a lot of food difficulties because the seasons are not like they used to be. Many people are just confined to their homes because of floods from the sea and from rain - cannot find food. Waiting for aid is also difficult because who wants to give or where to get it from, there are village funds but they are distributed and used up. As a result, many people, especially children, become sick, thin, have big stomachs, fever, and sometimes die". The Village Head of Atat - Markus Citur explained:

"we get little village funds in December, that's for celebrations and we usually distribute it all. In the past, people didn't have food difficulties - until now this forest, river, and swamp have a lot of food ingredients but in recent years it's like there's a disturbance, namely the rainy season doesn't stop and big floods continue - plus the sea is also rising higher - people have difficulty finding food because they want to hunt, want to look for fish, want to extract sago - they can't".

The interview results explain that there is a fact of climate change which in local language by the community is called seasonal change or occurs in seasonal anomalies and impacts on the scarcity of food sources mostly produced by nature. The reality of local seasonal changes in As and Atat shows that food scarcity directly impacts nutritional intake for the body which under normal circumstances can be obtained from local food extracted from the forest.

The Influence of Climate Change on Malnutrition Cases in As-Atat Village in 2017/2018

Climate change is a global problem that occurs and is experienced both directly and indirectly by all human societies and all creations inhabiting this one and the same earth or world. It cannot be denied and is very unfortunate that the group most vulnerable and affected by climate change is indigenous peoples who live in the midst of forests, whose livelihoods depend on forest or natural products. When the climate changes, nature and the environment will also be affected - changing and the balance of the ecosystem will also change.

The As and Atat indigenous people live in the ecology of peat swamps and mangrove forests and depend entirely on nature's production for their livelihoods, especially food. Throughout the history of environmental management practices, they have various local wisdoms to keep the forest and environment intact and sustainable from generation to generation as mandated and inherited by their ancestors. The unity and dependence on the environment is personified in the mythology of Asmat humans originating from trees (tree trunks) or Asmat women being the same as sago trees. Such personification becomes a spirit for every Asmat - As Atat indigenous child to treat nature and the environment like themselves by guarding, caring for, protecting so that it is not damaged, destroyed, and perished. Self-awareness in relation to nature proves that until now, the Asmat indigenous people and especially As and Atat do not consciously and directly carry out actions aimed at damaging or destroying the forest or environment where they live. Like indigenous peoples in general, they actually play a large and active role in protecting and preserving forests not because of climate change issues but because of the spirit and calling of life for environmental sustainability and also means the sustainability of indigenous communities and the future of children and grandchildren.

Today, indigenous peoples face and experience a tragedy of life in harmony and balance with nature due to the disaster of climate change (Ngcamu, 2023; Sayuti et al., 2023a, 2023b). Climate change with its various impacts has come and even become a ghost that threatens the balance of ecosystems and indirectly threatens the livelihoods of indigenous peoples as part of the ecosystem. The threat of climate change is a reality for the As and Atat Indigenous People today. The El Nino case in mid to late 2015 which impacted on prolonged drought; the Asmat Malnutrition Outbreak problem from late 2017 to early 2018; and

recently the El Nino disaster with drought in November - December 2023 which impacted on crop failure and delays in planting also affected the Asmat Indigenous People in As and Atat Villages.

Our observations in As and Atat Villages show that there is an important correlation between climate change that impacts changes in food-seeking seasons and food security sourced from nature with malnutrition cases that occurred in the Asmat Indigenous People, especially As and Atat Villages. The connection between these two things can be understood that the As and Atat Indigenous People live in an ecology (ecosystem) that is rich in natural resources, especially sufficiency of food sources for livelihood. The environmental carrying capacity in producing sufficient and sustainable food is highly dependent on stability and regularity factors. In other words, if the climate changes, the balance and productivity of the ecosystem will experience problems so that humans who are part of the ecosystem will also be affected. The As and Atat indigenous people live in an ecosystem where in fulfilling their livelihoods, they are very dependent on other ecosystems: forest products, rivers, streams, and swamps. When the balance and productivity of the ecosystem following the annual cycle is disrupted due to climate change or seasons, humans also experience a crisis and imbalance in fulfilling their livelihoods.

Climate Change Phenomena and Seasonal Changes

Understanding climate change in the local context of the Asmat indigenous people must be placed and understood in the cycle - dynamics of life based on seasons. The season is a reference or livelihood calendar that is associated with the rhythm of nature based on weather changes, forest rainfall, floods, tidal patterns with a fairly regular annual cycle. The annual seasonal cycle becomes very important because it becomes a calendar that guides the As - Atat indigenous people in ensuring productivity, availability, and sufficiency of various food sources in supporting livelihoods over a one-year period. The seasonal cycle is determined based on the natural productivity of the environmental carrying capacity (sago and various fruit trees in the forest, hunted animals, fish/shrimp, etc.) which is adjusted to hydrological conditions (rainfall - floods, tidal patterns) and time (dry months - wet months). The regularity of seasons between normal hydrological cycles and routine dating according to natural signs that are routinely confirmed to occur in the same month in one year, it can be ensured that the rhythm and productivity of nature will run in balance and also means that there is a balance of life for all ecosystems and especially humans because of the availability of sufficient food sources for livelihood. When the seasonal rhythm is disturbed by changing weather patterns such as (prolonged dry or wet seasons); hydrological patterns (shifting seasons and high rainfall resulting in prolonged flooding; increasingly frequent and higher sea level rises beyond normal limits - submerging all land), shifting or failing annual regular production and harvest cycles (forest trees or cultivated plants not producing and yielding according to regular annual seasons) then it can be ascertained that the As and Atat Indigenous People are in a problem of ecosystem balance and livelihood resilience. Nature cannot speak with words other than signs and results or impacts caused. The low literacy of the community makes them slow to read and understand climate change manifested in seasonal changes, so there are no local-based adaptation or mitigation efforts that must be made to survive.

The reality of climate change is shown in a time series of very high rainfall levels in Asmat, namely at 300-400 mm/month or 3500-4500 mm/year, and even as in other places, the impact of El Nino brings prolonged drought to the As - Atat indigenous people. The condition of sea level rise that is getting higher from year to year, such as the figure in March 2023 at the level of 5.3 m, means it has risen 1 cm from the previous year. In almost ten years, if using a comparative figure of 1:10, then every sea level rise at an indicator of 1cm is equal to 10 cm. If such an indicator comparison figure is used, the tragic impact of climate change and the resilience of indigenous peoples in livelihoods, especially food sufficiency, can be concluded.

The As and Atat Indigenous People verify and confirm the indicative figures based on meteorological data on rainfall and the phenomenon of sea level rise from their experience of changes in nature and the environment around them. Indigenous people show significant facts of seasonal change conditions, among others: 1) Sea level rise in the last 10 years is higher than before, evidenced by sea level rise exceeding house floors and also submerging all land without - forests and yards; 2) rainfall has shifted from the

seasonal cycle - months that are usually dry/drought have changed to months with high rainfall and flooding, conversely months with high rainfall have become dry/drought months; 3) Measuring and comparing the height of the house floor from the ground surface of 1m and the height of water submersion from above the house floor of about 10 - 15 cm, it becomes clear that there is a drastic change in sea level rise or it can be said to be an extreme rise. This comparison is important to see that the height of building/house poles is always adjusted to the highest limit of sea level rise or flooding so that if now the house floor is already submerged in water, it means that changes have occurred and adaptation and mitigation must be carried out. Another fact that still needs to be studied in depth is the erosion and shifting of coastlines, the destruction of mangrove ecosystems on the coast, and the shifting of community houses as far as about 30m - 50m in the last 10 years along the Asmat coast from the Pulau Tiga area in the West to the Pirimapun area in the East. All the facts above directly and indirectly prove the reality of climate change that impacts the ecology and balance of ecosystems where the As and Atat Indigenous People live.

Food Crisis and Malnutrition

The fact of climate change or in local language known as seasonal change points directly to changes in food production and food security of the As and Atat Indigenous People. As and Atat food production is 90% dependent on natural production - forests which are also very dependent on the rhythm and stability of the seasonal cycle. Climate change with various indicators that have been described previously has a direct impact on seasonal changes, production systems, and environmental carrying capacity for livelihoods that become real in the food crisis. The food crisis due to seasonal changes where the annual production season of forest plants/trees and other food sources is disrupted, cultivated yard crops are damaged and destroyed (crop failure), humans are not free to extract forest products due to rain - sea level rise and flooding.

The measurement results of the nutritional adequacy rate from local food sources and consumption patterns show that the As and Atat communities have a nutritional adequacy rate higher than the National standard. The nutritional adequacy rate as measured assumes a stable, balanced ecological condition, and the annual forest/natural production seasonal cycle runs regularly. Nutritional adequacy is obtained from food sources extracted from the forest according to the supply season. With the changing rhythm of the seasons marked by various natural phenomena impacting the carrying capacity and productivity of the environment on the provision and availability of food sources that directly impact the availability and adequacy of nutritional intake in humans. Human nutritional adequacy in the form of carbohydrates, proteins, fats, and other substances is mostly obtained from local food sources, so when the production and availability of local food sources are disrupted, reduced, or can be said to be in a period of extreme food crisis, automatically the availability and adequacy of nutrition for the body also experiences shortages/crisis. Lack of food sources and limited food containing nutrients for the body will have a direct impact on nutritional deficiencies, low body resistance to various illnesses and diseases. The case of the Asmat Malnutrition Outbreak in late 2017 and early 2018 starting from As and Atat Villages can be concluded as a result of climate change that impacts the lack of food adequacy and impacts on lack of nutritional intake which manifests as a health problem of Malnutrition in most children 0 - 12 years old. Children become the most vulnerable population due to limited nutrition received from mothers for those who are breastfeeding, or limited access and consumption to food that has been dominated by adult males. Medically or health-wise, a correlation can also be found between food adequacy, nutritional adequacy, body resistance, and physical and spiritual health of each individual (Ford, 2012).

5. Synopsis of the Main Research Outcomes

For the As and Atat Indigenous People and Asmat in general who are very dependent on life and fulfillment of livelihood, especially food security on nature, in the principle of causality, it becomes clear that when nature experiences changes or imbalances in the rhythm of the seasons, it will have a direct impact on the imbalance of food production and adequacy. This also means a food crisis that can impact nutritional deficiencies that give birth to malnutrition diseases. The reality of the Malnutrition Outbreak in Asmat, As and Atat villages becomes an irony like 'rats dying in rice barns' or in the local context 'pigs dying in sago groves' if not seen in relation to the impact of climate change.

This study on the impact of climate change on food security and malnutrition in the As and Atat indigenous communities of Papua, Indonesia, reveals a complex interplay between environmental changes, traditional food systems, and community health. The findings paint a picture of communities deeply connected to their environment, yet increasingly vulnerable to the effects of global climate change (Muttaqin, 2023a; Muttaqin, 2023b). Significant alterations in local climate patterns were observed, with average monthly rainfall increasing to 300-400 mm/month and sea levels rising dramatically, peaking at 5.3 m in March 2023. These changes have had profound implications for the communities, whose food sources are predominantly (90%) derived from the forest.

The research uncovered a paradoxical situation regarding nutritional status. Under normal conditions, these communities maintain a Nutritional Adequacy Rate (AKG) 205% above the national standard. However, climate-induced disruptions have led to periods of acute food scarcity, exemplified by the Asmat Malnutrition Outbreak of 2017-2018. This event highlighted the precarious balance between environmental stability and nutritional health, particularly for the most vulnerable group identified in the study: children aged 0-12 years.

Community members demonstrated a keen awareness of these environmental shifts, describing "chaotic" seasons and the destruction of vital plant resources. Their testimonies provide vivid illustrations of how climate change is reshaping traditional ways of life. Despite this awareness, the study found limited local-based adaptation or mitigation efforts, attributed in part to low literacy rates and resource constraints. This gap between perception and action emphasizes the need for targeted, culturally sensitive interventions. The research also shed light on the socio-economic dimensions of food security in these communities. It revealed how limited village funds and their allocation patterns contribute to the challenges in addressing food insecurity during climate-induced scarcity periods. This finding emphasizes the need for a holistic approach to food security that considers not only environmental factors but also economic and governance aspects.

6. Conclusions

Living from nature and livelihoods that depend on the production cycle and environmental carrying capacity with seasonal patterns is a vulnerable reality. Vulnerability occurs because of dependence where the determining and controlling factors are in nature which is very dynamic and can change at any time. Facing such vulnerable conditions, the Asmat Indigenous People, especially As and Atat, certainly have various local solutions, but due to the extreme changes, they experience seasonal shock and are late in carrying out various adaptation and mitigation processes against climate change and food security during times of crisis. Besides that, stakeholders, both government and private, have not seen and made the cases of Malnutrition, Local Food Security, and Climate Change as strategic issues and development priorities for communities living in the midst of peat swamp ecology - mangrove forests where the fulfillment of food needs for livelihood is very dependent on nature.

All parties, both Indigenous Communities, Church Institutions, NGOs, and especially the Asmat Government, need to see and realize that there is a very close correlation and connection between climate change - food security and malnutrition. If it is acknowledged that the Asmat people, especially As and Atat, are gatherer communities where most of their food needs and household consumption still depend on and are extracted from nature, it is also logical that when nature experiences an imbalance in terms of seasonal changes, it cannot be avoided that the productivity of nature in the form of environmental carrying capacity on food sources is also disrupted. The disruption of productivity and availability of food in nature or forests gives birth to a food crisis for communities living from nature. A prolonged food crisis creates various new problems and is directly connected to nutritional deficiencies that culminate in cases of malnutrition. This article comprehensively demonstrates that the future tensions of climate change not only reveal conceptual tensions but also at the level of praxis of political channels, sustainability agendas, and indigenous-based food development that are wide open for further research.

7. Limitations, Implications, and Further Directions of Research

While this study provides valuable insights into climate change impacts on indigenous communities in Papua, several limitations must be acknowledged. The focused geographic scope on As and Atat villages in the Asmat Regency, while allowing for in-depth analysis, may limit generalizability to other indigenous communities. Time constraints potentially hindered the capture of long-term climate change trends and community adaptations, a limitation exacerbated by the scarcity of historical data on local climate patterns and health outcomes. Despite efforts to bridge cultural gaps, language barriers may have resulted in the loss of nuanced local perceptions and experiences. The reliance on self-reported data introduces the possibility of recall bias, particularly for historical information. Finally, the remote nature of the communities and limited healthcare infrastructure restricted access to comprehensive quantitative data on malnutrition rates over time, potentially affecting the robustness of health-related conclusions. These limitations emphasize the need for cautious interpretation of the results and highlight areas for future research to address these constraints.

Moreover, the findings of this study have significant implications across multiple domains, underscoring the need for a holistic approach to addressing climate change impacts on indigenous communities in Papua. Foremost, there is an urgent need for climate change adaptation policies that specifically address the unique vulnerabilities of these communities, considering the intricate relationships between climate, traditional food systems, and community health. The integration of climate change considerations into health interventions, particularly those targeting malnutrition, is crucial for achieving sustainable health outcomes. The research also highlights the necessity of incorporating indigenous knowledge into sustainable environmental management practices, which could mitigate negative climate impacts while preserving cultural practices. Furthermore, food security strategies in the region require reconsideration, potentially involving the development of climate-resilient approaches to food production and distribution. The study emphasizes the importance of preserving indigenous knowledge and practices, not only for cultural heritage but also as a valuable resource for informing climate adaptation strategies. Lastly, the complex interplay of factors revealed in this research calls for more interdisciplinary approaches in addressing climate change impacts on indigenous health, suggesting increased collaboration among climatologists, anthropologists, health professionals, and indigenous knowledge holders. These implications collectively point towards a comprehensive, culturally sensitive, and interdisciplinary approach to tackling the challenges posed by climate change to indigenous communities in Papua and potentially beyond.

Finally, this study's findings and limitations point to several crucial avenues for future research. Longitudinal studies are imperative to track long-term changes in climate patterns, food availability, and health outcomes in As and Atat villages and similar communities, providing more robust evidence of trends and causal relationships. Complementary comparative studies encompassing other indigenous communities in Papua and beyond could illuminate common patterns and unique challenges across diverse contexts. To address health data limitations, implementing comprehensive quantitative health assessments is recommended, offering clearer insights into malnutrition trends and their correlation with environmental changes. Concurrently, developing localized climate models could enhance the accuracy of climate change impact predictions in these specific geographic areas, facilitating more targeted adaptation strategies. Future research should also evaluate the effectiveness of various climate change adaptation strategies, including the integration of traditional ecological knowledge with scientific approaches to bolster community resilience. Furthermore, exploring gender-specific impacts of climate change and food insecurity within these communities could reveal critical vulnerabilities and resilience factors among men, women, and children. These diverse research directions collectively aim to deepen our understanding of climate change impacts on indigenous communities and inform more effective, culturally appropriate interventions and policies.

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