

TRANSFORMATION OF LIFE NEEDS MEETMENT BASED ON LAKES AND SAGO FORESTS IN THE NENDALI COMMUNITY IN EAST SENTANI

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Abstract

This study examines the transformation of livelihood strategies among the Nendali community in East Sentani District, Jayapura Regency, Papua Province, whose subsistence system has historically depended on Lake Sentani's ecosystem and sago palm forests. Over centuries, both natural resources have served not merely as economic foundations but also as cultural anchors and social bonds for the community. However, rapid infrastructure development, large-scale land conversion, and the expanding penetration of market-based economies have forced the local population to fundamentally readjust their livelihood orientations. Using a qualitative ethnographic approach, this research finds that a multidimensional shift has occurred from nature-based subsistence systems toward economic diversification involving trade, services, and wage labor. These changes have further implications for gender relations, the continuity of local ecological knowledge, and the effectiveness of customary institutions in managing natural resources. This study underlines the urgency of integrating Nendali's indigenous wisdom with more responsive and socially just regional development policies.

Keywords: Livelihood Transformation; Lake Sentani; Sago Forest; Nendali Community; Papuan Ethnography

INTRODUCTION

The dependence of indigenous communities on coastal lake resources and sago forests is not unusual, but rather a proven livelihood system for hundreds of years. However, what is striking is the speed and depth of change that has swept through this system over the past two decades. In the East Sentani area of Jayapura Regency, the expanse of sago forest, which has long been the livelihood of the Nendali community, has experienced a spatially measurable decline. Rorrong, Safkaur, and Ramandei noted that in the five-year period between 2015 and 2020, the area of sago forest cover in Nendali Village shrank by 114,629.76 m², with most of it converted to scrubland due to logging and landfilling, while some has been converted into built-up areas for housing and roads (Rorrong, Safkaur, and Ramandei 2024, 71). This figure is not simply spatial data; It reflects the rapid erosion of the ecological foundations that have ensured food security and the cultural identity of the Nendali people by development pressures. Similar phenomena have been documented in various indigenous Pacific communities, where accelerated modernization consistently correlates with the weakening of customary-based resource management systems (Li 2010, 385).

Several researchers have focused on environmental degradation and social transformation in the lake and sago forest areas of Papua. Mansoben, in his study of the traditional political system of Irian Jaya, emphasized that the ondoafi leadership structure plays a central role in regulating the distribution and access to natural resources, including sago areas and lake waters (Mansoben 1995, 112). From an ecological perspective, Botanri et al. explain that the natural habitat of sago plants in Papua is highly vulnerable to hydrological disturbances and land conversion, given its dependence on moist and water-rich soil conditions (Botanri et al. 2011, 138). Meanwhile, Ibrahim and Gunawan note that the conversion of sago palm areas in eastern Indonesia often occurs without in-depth studies of its social and cultural impacts on local indigenous communities (Ibrahim and Gunawan 2015, 1067). However, most of these studies focus on structural or spatial analysis, failing to adequately address how communities at the household and community levels actively respond, negotiate, and adapt to the ecological changes that occur. This area is the blind spot that this paper seeks to address: how this livelihood transformation manifests itself in the daily lives of the Nendali community, what factors drive it, and what impacts it has on the community's socio-cultural life.

Based on this gap in research, this paper establishes three main questions that serve as the writing's compass. First, what is the concrete manifestation of the transformation in fulfilling the needs of the Nendali community in relation to the use of Lake Sentani and sago forests? Second, what structural and cultural factors drive and hinder this livelihood transformation process at the community level? Third, what impacts does this livelihood transformation have on the social structure, cultural sustainability, and ecological resilience of the Nendali community as a whole? These three questions are deliberately formulated in a hierarchical manner so that the study can move from phenomenological description to a more comprehensive causal analysis and impact assessment, thus producing findings that are not only descriptive but also analytical and prescriptive for the benefit of public policy at the regional level. The author argues that the livelihood transformation that occurred in the Nendali community cannot be understood solely as a rational individual response to market economic incentives. This transformation is a dialectical process between external structural pressures, in the form of development policies, infrastructure expansion, and market dynamics, and the community's internal agency capacity that comes from their customary systems, social networks, and local ecological knowledge. In other words, the Nendali community is not a passive object simply accepting the flow of change; they are actors actively negotiating their identity, survival strategies, and relationship with nature amidst increasing pressures. This understanding is crucial because it determines the policy direction that needs to be taken, namely not merely a technocratic empowerment program from above, but rather an approach that recognizes and strengthens the community's adaptive capacity from within, by positioning local wisdom as an integral part of the solution, rather than an obstacle to be overcome.

To answer the formulated questions, this study uses a qualitative ethnographic approach that prioritizes the researcher's direct involvement in community life. Data collection was conducted over approximately four months in Nendali Village, East Sentani District, combining three main techniques. The first technique is participant observation in daily community activities such as fishing, sago processing, and market activities. The second technique is in-depth semi-structured interviews with 15 key informants including traditional elders, ondoafi leaders, active fishermen, female sago processors, and youth leaders. The third technique is a focus group discussion involving three different groups to validate and expand the interview findings. The collected data were analyzed using an inductive thematic approach with triangulation of sources and methods to ensure the validity and reliability of the resulting findings.

SETTING: GENERAL OVERVIEW OF NENDALI VILLAGE

Nendali Village is located in East Sentani District, Jayapura Regency, Papua Province, and is one of many traditional settlements surrounding the shores of Lake Sentani, Papua's largest lake, spanning approximately 9,360 hectares. Nendali Village's geographical position is very strategic, as it lies at the intersection of the rapidly expanding urban area of Sentani and rural areas that still retain their natural character. Administratively, the village covers an area of 5,672 km² and borders the Nolakla area to the north, Ifar Besar to the south, and Sentani City to the west (Rorrong, Safkaur, and Ramandei 2024, 67). Its relatively good accessibility via provincial roads prevents the village from being economically isolated, but at the same time makes it vulnerable to various external pressures arising from urban expansion and the rapid flow of goods and people.

Lake Sentani is both the geographical and cultural soul of the Nendali people. The lake's vast, rich waters, rich in freshwater biota, have never been viewed merely as a source of animal protein; it is a social space where community members meet, an arena for inter-clan exchange, and a spiritual medium connecting humans with ancestors and the forces of the cosmos. In Sentani cosmology, the lake is believed to be the abode of guardian spirits who ensure the fertility and safety of the community (Mansoben 1995, 89). Therefore, fishing activities in the lake are always accompanied by a series of ethics and traditional rituals that regulate who may fish where, when, and with what equipment. This regulatory system is not merely a symbolic tradition, but rather a highly effective resource management mechanism in preventing overexploitation and maintaining the sustainability of aquatic ecosystems.

On the land side, the Nendali Village area is surrounded by expanses of sago forest that ecologically form a green belt between the settlements and the lake waters. The sago palm (*Metroxylon sagu* Rottb.) that dominates this area grows in the humid conditions typical of tropical lowlands, with elevations not exceeding 700 meters above sea level and abundant rainfall throughout the year (Botanri et al. 2011, 136). The sago forest in Nendali is not a monoculture; it grows intertwined with various other vegetation types such as nipah palm, swamp pandanus, and various local fruit plants, forming a rich and diverse mixed forest ecosystem. This ecological diversity makes the sago forest not only a producer of starch, but also a buffer zone that filters surface runoff, maintains the stability of the lake shore, and provides habitat for aquatic and terrestrial fauna.

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Demographically, Nendali Village is inhabited by a highly ethnically homogeneous community, the majority of whom are descendants of the indigenous Sentani people, divided into several clans or marga (marga) linked through genealogical ties and intermarriage. Each clan has a customary territory encompassing the lake, sago forests, and cultivated land, which is passed down through the patrilineal line. This inheritance system has resulted in a highly detailed map of customary ownership, where each sago grove and fishing zone can be traced back to a specific ancestor. In recent decades, natural population growth combined with the arrival of immigrants from other regions of Indonesia has gradually changed the village's demographic composition, increasing pressure on existing resources and complicating customary governance.

The governance system in Nendali Village operates through two complementary yet sometimes conflicting channels: the formal governmental channel through the village head and his staff, and the customary authority channel through the ondoafi institution. Ondoafi is the highest title in the Sentani customary leadership hierarchy, with its holder having the authority to regulate natural resource management, resolve inter-clan disputes, and maintain a balanced relationship between humans and nature. In the context of development, the ondoafi's role is crucial because any decision regarding customary land use normatively requires its approval. However, in practice, the ondoafi's authority is increasingly being displaced by external development interests, particularly when there is compelling economic pressure on individual clan members.

From a regulatory perspective, sago forest areas in Jayapura Regency are formally protected by Jayapura Regency Regulation Number 3 of 2000 concerning the Conservation of Sago Forest Areas. This regulation defines sago forests as protected areas that cannot be converted without a strict permit mechanism, while also recognizing the social, economic, and ecological value of sago forests for local indigenous communities. However, the gap between the regulatory text and the reality on the ground is wide. Research by Rorrong et al. shows that despite the regulation having been in effect for more than two decades, sago forest conversion in Nendali Village continues without significant obstacles (Rorrong, Safkaur, and Ramandei 2024, 73). This weakness stems largely from the absence of effective law enforcement mechanisms and minimal public outreach to the regulations.

The livelihoods of the Nendali community have traditionally relied on three main pillars: fishing in Lake Sentani, harvesting and processing sago from the surrounding forest, and small-scale gardening to meet their vegetable and fruit needs. These three activities are not only economic but also shape the community's daily social rhythms. In the morning, fishermen descend on the lake; from midday to evening, women process sago and prepare meals; and late afternoon and evening are times for social gatherings and the exchange of information among neighbors. This structured rhythm of life began to shift noticeably with the influx of job opportunities in the construction and trade sectors offered by the expansion of Sentani city in the late 1990s.

Infrastructure in Nendali Village has undergone significant improvements over the past decade and a half. The construction and widening of the provincial road that cuts through the village has improved connectivity with downtown Sentani, streamlining the distribution of catches and sago products to markets, and opening up access to various urban services such as education, health care, and banking. However, these infrastructure improvements have come with significant ecological consequences; parts of the widened road pass through sago forests, resulting in the felling of several irreplaceable sago groves. Furthermore, this ease of access has also stimulated demand for land for new settlements, both from local residents seeking better homes and from newcomers attracted to areas increasingly accessible from the city center.

The current economic system of the Nendali community can be described as a dual economy still in transition. On the one hand, some households, especially those headed by the older generation, still maintain subsistence activities such as fishing and sago harvesting as part of their weekly routine, even though they are no longer their primary source of income. On the other hand, the younger generation who have received formal education are increasingly absorbed in salaried jobs in the service sector, government, or small-scale trading at Sentani Market. The combination of these two economic orientations has resulted in a unique consumption pattern, with Nendali families generally still consuming papeda and lake fish as staple foods, but purchasing them from the market rather than processing them themselves, marking a shift from subsistence production to market-based consumption.

In terms of education, the participation rate of children in the formal education system in Nendali Village has increased rapidly over the past two decades thanks to the construction of elementary and secondary schools within easy reach of the village. This improvement in education has had a dual impact on transforming livelihoods. On the one hand, it has opened access for the younger generation to a wider variety of potentially more financially rewarding employment opportunities. On the other hand, it has also created a cultural distance between the urban-oriented younger generation and the older generation, who still adhere to nature-based values and practices. This

intergenerational tension is a significant manifestation of the ongoing cultural transformation, where ecological knowledge about the lake and sago is no longer automatically passed on through informal socialization. The overall picture of the setting above shows that Nendali Village is a community situated precisely on the line of tension between tradition and modernity, between ecological integrity and development pressures, between customary autonomy and state intervention. Understanding the complexity of this context is crucial to avoid potentially misleading analytical simplifications. The livelihood transformation occurring here is not simply a matter of progress or regression, but rather a complex process of negotiation between various forces moving in different directions and at different speeds. It is within this contextual framework that subsequent analysis needs to be positioned so that the findings truly reflect the reality experienced by the Nendali community.

FORM OF TRANSFORMATION IN FULFILLING LIFE'S NEEDS

The most tangible and measurable manifestation of the transformation of the Nendali community's livelihoods is the dramatic reduction in sago forest area, which directly erodes the community's local food production base. Spatial data compiled by Rorrong, Safkaur, and Ramandei through multi-temporal satellite imagery analysis shows that between 2015 and 2020, the area of sago forest cover in Nendali Village decreased from 1,186,570.92 m² to 1,071,941.16 m², a reduction of 114,629.76 m², or approximately 9.66 percent of the initial area, in just five years (Rorrong, Safkaur, and Ramandei 2024, 71). This reduction was not uniform; it occurred through three distinct modes of conversion. First, 5,864.59 m² was converted into built-up land in the form of permanent buildings and road infrastructure. Second, 5,284.53 m² has been converted into open land, indicating that the land is in preparation for development. Third, the largest area, 201,793.95 m², has been converted into scrubland due to logging and landfilling without immediate development.

The shift from traditional fishing systems to more commercial and extractive patterns is the next most visible transformation in the daily lives of the Nendali people. Previously, Nendali fishermen used traditional fishing gear such as woven traps, hand nets, and spears, which allowed for high selectivity in the type and size of fish caught. These gear were used within customary zones, allowing for rotations and breaks in fishing that de facto prevented fish stock depletion. However, in the past two decades, increasing economic pressures have driven some fishermen to switch to using far more efficient but less selective monofilament nets, extending the duration and intensity of fishing beyond the limits previously recognized by custom. This shift in fishing technology is a concrete indicator of the weakening of customary norms that support the sustainability of aquatic resources.

The transformation in sago processing practices represents one of the most culturally rich manifestations of change. Traditionally, sago processing involved the entire extended family, sometimes even across clan boundaries, in a collaborative effort with social and ceremonial dimensions. The process of felling the sago trunk, splitting it, tapping the pith, and then squeezing the flour out of it was carried out in a work cycle that could last several days and was always accompanied by conversation, oral storytelling, and sometimes traditional singing. This entire series of activities was a crucial arena in which knowledge about sago, the natural environment, and community values was transmitted from older to younger generations. Today, this process is increasingly rare as a collective process; some families choose to purchase prepackaged processed sago flour from market vendors, replacing communal labor with time-efficient but culturally impoverished monetary transactions.

Shifts in food consumption patterns are the most directly felt transformation in daily life and are also the most powerful change in people's relationships with their local ecosystems. Papeda, a sago porridge dipped in fish sauce, which was once a staple food consumed two to three times a day, is now being replaced by rice as the staple food in many Nendali households, especially young families. This is corroborated by the testimony of Yanfit Wali, the local ondoafi, who stated that sago remains a staple food in the Sentani area, but now rice has become a supplement. According to him, indigenous Papuans in Sentani rely on sago as their staple food, and if they do not consume papeda sago, they feel inadequate (Yanfit Wali, interview, 2024). This ondoafi's statement aptly illustrates the tension between local food identity and the pressures of modernization that continue to drive a shift in consumption toward marketed foods.

***Yanfit Wali (Ondoafi Nendali):** "Sago is still a staple food, but here we also have rice, so generally, like the indigenous people of Papua, we in Sentani, sago is the main food. Well, in Indonesia, rice is the main food, but here, people don't eat papeda, but sago, it feels like it's not enough."*

The emergence of Nendali's younger generation as wage-based economic actors represents the most visible manifestation of livelihood transformation in the demographic structure of the village workforce. Young people of productive age between 18 and 35 are now increasingly absorbed in the construction sector, motorcycle taxis and

boat transportation, retail trade, and to a lesser extent in formal government and private employment. This shift in work orientation is not solely driven by economic calculations; it also reflects a transformation in aspirations and identities. For many young Nendali, working in the city, or at least in the non-agricultural sector, is seen as a sign of social progress and educational success. This view, while understandable in context, is slowly eroding the regeneration of skilled workers in fishing and sago processing, which are crucial for ecosystem sustainability and local food security.

The transformation of women's roles in the Nendali household economic system represents a change that simultaneously carries the potential for empowerment and the risk of exploitation. Traditionally, Nendali women held a strong position in the domestic and semi-public spheres; they managed the distribution of their husbands' fish catch, processed sago flour for family consumption, and maintained food exchange networks with other families. Now, with the decline in subsistence production, women are increasingly taking on active roles as traders at Sentani Market, selling fresh fish, smoked fish, sago flour, and a variety of traditional processed food products. The economic independence generated by this trading activity provides women with new autonomy, including greater access to household decision-making, but their workload doubles as domestic responsibilities persist while the demands for productive work in the market continue to increase.

The erosion of traditional ecological knowledge is the most subtle yet potentially most damaging form of transformation in the long term. Interviewed Nendali elders consistently expressed deep concern about the loss of specific knowledge that has enabled the community to manage resources sustainably. This includes knowledge of Lake Sentani's endemic fish species and their habitats, how to read natural signs to determine optimal sago harvesting times, rituals that place humans in a mutually nurturing relationship with nature, and traditional techniques for building wooden boats suited to the lake's waters. This knowledge is not codified in written texts; it lives on in intergenerational practices, conversations, and demonstrations that are becoming increasingly rare as the chain of transmission is broken due to the changing orientation of the younger generation.

Changes in land ownership and access systems represent the most potentially conflictual transformation in the medium term. Traditionally, ownership of sago groves and use rights to lake zones are regulated through a communal clan-based customary rights system. However, pressures for capital and the lure of rising land prices with urban expansion have prompted some clan members to engage in land sales or leases with outsiders without proper customary deliberation mechanisms. This phenomenon creates internal tensions within clans and weakens community cohesion, as these individual decisions have the collective consequence of reducing the land accessible to all clan members. In some cases, informally sold land has even become the source of protracted disputes between clan members who feel their rights have been violated.

Changes in the frequency and substance of traditional rituals related to livelihoods represent a transformation that reflects a shift in value orientation at the deepest level. Ceremonies that once routinely marked the beginning of the fishing season, the sago harvest, or the distribution of agricultural produce are now held less frequently in their entirety, or when they are held, they increasingly lose their spiritual dimension and become merely ceremonial-decorative cultural performances. This simplification of rituals reflects a weakening of the cosmological connection between the Nendali people and the ecosystem that sustains them, a shift that, in the long term, could weaken the community's internal motivation to preserve the environment considered sacred by their ancestors.

FACTORS DRIVING AND INHIBITING TRANSFORMATION

The most dominant factor driving the transformation of the livelihoods of the Nendali community is the massive expansion of infrastructure development that has been underway in Jayapura Regency since the mid-2000s. The widening and construction of new roads connecting Nendali Village to the center of Sentani has had two simultaneously contradictory consequences: on the one hand, it has increased accessibility and mobility for residents, while on the other hand, it has directly converted the sago palms along which they pass. Rorrong and colleagues note that part of the 5,864.59 m² of developed land that was previously a sago forest area is now part of the road and buildings directly related to the infrastructure project (Rorrong, Safkaur, and Ramandei 2024, 72). Paradoxically, the same infrastructure that destroyed parts of the sago palms also serves as a means for the community to sell sago products to a wider market, creating a dependency that is difficult to unravel.

Demographic pressure in the form of rapid population growth is a driving factor for transformation that is working slowly but continuously to erode sago forest areas from within the community itself. Population growth, both through natural growth and migration from other areas, creates a growing demand for residential land, ultimately eroding sago forest areas directly adjacent to existing settlements. In the context of Nendali culture, which recognizes inheritance rights to sago land based on lineage, each new generation forming a nuclear family requires new land to

build a home, and sago areas on the outskirts of settlements are the most practical and convenient option. This dynamic creates organic land conversion pressures within the community itself, which differ in character from external pressures resulting from outside development investment but are equally damaging to the ecosystem. The introduction of a market-based economy, with all its attractions, is a driving force that operates through psychological and aspirational channels, not simply economic mechanisms. When community members begin to perceive that income from wage labor or market trade can generate cash more quickly and substantially than the labor of cultivating sago for days, this comparison naturally influences their choices about allocating time and energy. Limbongan notes that although sago's calorific and economic value per hectare is comparable to that of other food crops, the high labor costs of its processing pose a competitive barrier when measured by the standards of a monetary economy (Limbongan 2007, 19). The appeal of cash income is also reinforced by the rise of new needs that can only be met with money, including education, smartphones, modern clothing, and the desire for a lifestyle associated with progress and social mobility.

The weaknesses in the implementation of sago forest protection regulations are a factor that paradoxically accelerates transformation rather than hinders it. Jayapura Regency Regulation No. 3 of 2000 normatively provides comprehensive protection for sago forest areas, including a prohibition on unauthorized conversion and mandatory conservation. However, in practice, this regulation faces several fatal structural weaknesses. First, the lack of field supervisory officers specifically tasked with monitoring sago forest conditions. Second, the limited public dissemination of the regulation's contents. Third, the absence of a firm and consistent sanction mechanism. Fourth, infrastructure development interests are often used as a basis for exemptions from protection provisions (Rorrong, Safkaur, and Ramandei 2024, 73-74). This situation creates what can be called a loophole of impunity, where sago forest conversion can be carried out with very little legal risk.

The progressive ecological degradation of Lake Sentani is a driving factor that has a ripple effect on the overall transformation of livelihoods. Lake sedimentation accelerated by land clearing in the catchment area, the influx of domestic and agricultural waste through river flow, and the overall decline in water quality have created increasingly inhospitable conditions for the lake's fauna, which is the basis of fishermen's livelihoods. The decline in endemic fish populations in Lake Sentani, including high-value species such as the Sentani snakehead and the Sentani rainbow, has not only resulted in a quantitative reduction in catches but has also weakened the motivation of the younger generation to pursue a profession as fishermen, whose future is seen as increasingly less promising and unable to compete with income from other sectors.

On the other hand, several factors act as obstacles or at least counterbalances to the pace of transformation. One of the most significant is the persistence of the ondoafi customary system, which still enjoys strong moral legitimacy and social authority among senior community members. As long as the ondoafi's authority remains respected and recognized, it can serve as an institutional brake against arbitrary conversion of customary land. Mansoben emphasized that in the Sentani community, decisions concerning communal resources traditionally cannot be made unilaterally without involving customary leaders (Mansoben 1995, 115). The challenge ahead is how to strengthen this authority with formal legal instruments that can provide stronger protection and are not easily bypassed by development interests.

A strong cultural identity as a lake and sago community also serves as an obstacle to a full transformation from a subsistence system to a market economy. Although many community members have shifted to non-agricultural occupations, most maintain a strong emotional and symbolic connection to the lake and sago. This is reflected in their daily food choices, the practice of small rituals that are still maintained, and an identity narrative that consistently refers to their origins as a community born of the lake and sago. This identity attachment, while not always leading to concrete conservation actions, creates a psychological foundation that can be mobilized to support cultural and ecological revitalization efforts if community leadership is able to channel it appropriately and consistently.

Community-based revitalization initiatives that have emerged in recent years represent a potential barrier to effective negative transformation. Women's groups in Nendali, for example, have begun replanting sago palms on previously vacant land, supported by a program from the local agriculture office. Meanwhile, some young people who migrated to the city and then returned to their villages have brought with them new entrepreneurial orientations that seek to combine local values with modern economic logic, for example by developing packaged processed sago products that market Papuan identity as an added value. These initiatives, while still small-scale and unsystematic, demonstrate that the capacity of community agencies to direct their own transformation toward a more sustainable path still exists and is in dire need of support.

The weak human resource capacity within local government institutions to understand and manage socio-ecological dynamics holistically is a contributing factor to the degradation process. Development policies at the district level are often sectoral, with public works departments planning roads without adequate coordination with environmental or agricultural departments regarding the potential impacts of land conversion. This weak cross-agency coordination results in conflicting policies: on the one hand, there are regional regulations protecting sago, while on the other, there are infrastructure projects that override those protections. Ondoafi Yanfit Wali's statement clarified this situation, expressing concern that almost all areas in Sentani are already beginning to appear vulnerable to loss due to the proximity to the provincial and district capitals, which bring significant development interests, while community-owned sago hamlets are increasingly being depleted (Yanfit Wali, interview, 2024).

***Yanfit Wali (Ondoafi Nendali):** "Almost all of the Sentani area has begun to disappear, and it looks like it could disappear because we are now in the district capital and the provincial capital, which is too close to development interests. Our hamlets are also disappearing day by day."*

Climate change, which alters rainfall patterns and water level fluctuations in Lake Sentani, is a driving force for transformation that is often overlooked in local policy discussions. Changes in the lake's hydrological patterns, such as increased frequency of extreme water level fluctuations, directly impact fisheries productivity and the condition of sago palms. Sago palms that remain inundated for prolonged periods due to unusually high lake levels experience physiological stress that can significantly reduce pith production. Conversely, more intense droughts during the dry season cause some normally moist sago palms to become excessively dry, disrupting natural regeneration processes. These climate-induced ecological changes exacerbate existing pressures, narrowing the community's adaptive capacity and diminishing the chances of ecosystem self-recovery.

IMPACT OF LIVELIHOOD TRANSFORMATION

The most fundamental impact of the transformation of the Nendali community's livelihoods is the weakening of local food security, which has been guaranteed by the availability of sago and lake fish as primary sources of calories that can be produced independently without relying on market mechanisms. As sago forests diminish and lake productivity declines, the community's ability to produce its own food also weakens, leading to greater dependence on external supplies of rice and other food products whose prices are vulnerable to fluctuations in regional and national markets. This condition theoretically places the Nendali community in a more vulnerable position to food security shocks, especially for households whose incomes are not stable enough to withstand increases in market food prices. Ibrahim and Gunawan warn that sago land conversion that is not accompanied by strengthening alternative food systems is likely to worsen the nutritional conditions of indigenous communities in the medium term (Ibrahim and Gunawan 2015, 1069).

The impact on the social structure of the Nendali community is manifested in the weakening of customary-based bonds of solidarity that were once strengthened through communal economic practices. Mutual cooperation in sago harvesting, sharing of fish catches among neighbors, and the inter-household food exchange system are social mechanisms that simultaneously fulfill both economic and social integration functions. As community members shift to individual, market-oriented economic activities, these mechanisms are increasingly practiced, reducing the frequency and intensity of social interactions that once served as the community's unifying force. In the long term, this weakening of social capital may result in a diminished collective capacity for the community to respond in an organized manner to the threats and challenges they face together as a customary entity.

In the cultural dimension, the most worrying impact is the accelerated extinction of ecological knowledge and cultural practices that have been developed over centuries through intensive interactions between humans and the sago lake ecosystem. Knowledge of the local names of plant and animal species in the lake ecosystem, survival techniques specific to local natural conditions, and cosmological narratives that give spiritual meaning to resource management practices are all at risk of being lost within the next generation or two without systematic documentation and revitalization efforts. This loss of knowledge is not merely an abstract cultural loss; it also concretely reduces the diversity of solutions available to communities in facing future sustainability challenges, as local knowledge has proven to have adaptive value that cannot be replaced by modern technology.

The impact on gender relations presents a paradox that requires a nuanced reading. On the one hand, women's increased involvement in public economic activities through market trading gives them greater access to financial resources and social networks outside the household, potentially strengthening their bargaining power in decision-making. On the other hand, field research finds that women's domestic roles have not been redistributed proportionally to their increasing productive workload outside the home. As a result, many Nendali women

experience a heavy double burden: they must wake up early to prepare for the family, then spend the day trading at the market, and then return home to fulfill unfinished domestic responsibilities. This situation suggests that economic transformation without a corresponding transformation in equal gender relations tends to increase the burden on women rather than reduce it. The long-term ecological impacts of this livelihood transformation have the potential to create a cycle of poverty and degradation that is difficult to break without systemic policy intervention. As sago forests diminish, their ecological function as natural filters for surface runoff, buffers for groundwater availability, and habitats for swamp wildlife also weakens. This ecological decline in turn worsens the water quality of the lakes that serve as the basis for fishermen's livelihoods, which then encourages more fishermen to abandon their profession and turn to other occupations, increasing pressure on the sago lands that serve as an alternative for conversion. This cycle of degradation will not be broken automatically by market mechanisms; it requires planned, consistent policy interventions based on a deep understanding of local socio-ecological dynamics that involve communities as key actors, not simply objects of development.

CONCLUSION

This research has successfully documented that the Nendali community in East Sentani District is undergoing a multidimensional and accelerating livelihood transformation. This transformation is manifested in a series of interrelated changes, including a spatially measured shrinkage of sago forest area of 114,629.76 m² between 2015 and 2020, a shift from traditional fishing systems regulated by custom to more intensive and extractive practices, a reduced frequency of communal sago processing, increased participation of the younger generation in the urban wage economy, a shift in the role of women to the realm of market trade, and an erosion of traditional ecological knowledge that occurs between generations. All these forms of transformation are manifestations of pressures coming simultaneously from various directions, namely from above through infrastructure development policies, from outside through market penetration, and from within through the aspirations of the younger generation for social mobility that is increasingly moving away from a nature-based subsistence orientation.

The factors driving transformation are structural and interlocking within a system that is difficult to unravel in isolation. Infrastructure expansion converting sago palms, demographic pressures, the lure of a market economy, weak enforcement of Regional Regulation No. 3 of 2000, and the ecological degradation of Lake Sentani are all driving forces operating synergistically. Conversely, inhibiting factors such as the persistence of ondoafi authority, the attachment of cultural identity to nature, and the emergence of community-based revitalization initiatives remain but face far greater pressure. Ondoafi Yanfit Wali's statement that community-owned sago hamlets are increasingly being depleted due to proximity to urban centers and development interests (Yanfit Wali, interview, 2024) serves as authoritative testimony confirming that the threat to the sago ecosystem is not merely a perception, but a reality directly experienced by community leaders.

The impacts of these livelihood transformations are ambiguous, presenting both opportunities and threats to community sustainability. Increased participation in the formal economy opens access to previously unaffordable services and opportunities, but simultaneously weakens food security based on local production, erodes social capital built through communal economic practices, accelerates the extinction of traditional ecological knowledge, and exacerbates ecological pressures on lake ecosystems and sago forests. Therefore, a development approach that solely measures progress based on conventional economic growth indicators is inadequate; an evaluation framework is needed that simultaneously integrates the dimensions of ecological sustainability, cultural integrity, and social justice so that the development process does not sacrifice the most fundamental basis of indigenous peoples' livelihoods.

Based on all the above findings, this study recommends three urgent agendas that need to be implemented simultaneously and in a coordinated manner. First, strengthen the implementation of Jayapura Regency Regulation No. 3 of 2000 through the establishment of a special sago forest monitoring team, operational sanction mechanisms, and systematic dissemination of regulations to all levels of society. Second, facilitate a documentation and revitalization program for the traditional ecological knowledge of the Nendali community through collaboration between the community, educational institutions such as IAIN Fattahul Muluk Papua, and the local government, so that this local intellectual property can be passed down to future generations in a structured manner. Third, develop a creative economic scheme based on local wisdom that will enable the Nendali community to improve their welfare without sacrificing the ecological and cultural base that underpins their identity and sustainability. These three agendas cannot be implemented separately and require cross-sectoral commitment from the government, civil society, and the Nendali community itself as the primary subject of development.

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