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Indigenous vegetables and household food security in a borderland community: Evidence from the Dayak Bidayuh of Entikong, Indonesia

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Abstract

Indigenous vegetables play a critical yet under-documented role in household food security among borderland communities in Borneo. This study examines how Dayak Bidayuh households in Entikong, Indonesia, integrate wild and cultivated plant foods into daily diets, cultural practices, and adaptive livelihood strategies within a rapidly modernizing Indonesia–Malaysia border economy. These transformations have been accentuated by recent disruptions, including the COVID-19 pandemic, the rise of commercial agriculture, and the proliferation of fast food and processed goods, which increasingly alter traditional foraging,

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cooking, and eating habits among younger generations.

Using a multi-site qualitative design supported by household interviews, participant observation, ambulatory foraging walks, and nutritional analysis, data were collected from 30 respondents across five villages reflecting varying degrees of market exposure and ecological access, as well as variation in gender related to age, occupation, or professional roles that spoke to food heritage and production.

Findings reveal five interrelated dynamics: hybrid subsistence and cash-based dependency, dietary transitions linked to Malaysian border markets, persistent cultural significance of indigenous dishes, erosion of ecological knowledge across generations, and gendered constraints in food provisioning. Despite increasing reliance on commercial foods, dishes such as *sayur rampai*, *ayam pansuh*, and *pekasam* remain essential to cultural identity, ecological memory, and social cohesion. The resulting Bidayuh Food Heritage and Food System Model highlights how access to land, knowledge transmission, ritual identity, and market dynamics collectively shape food security outcomes. Strengthening indigenous vegetables and cultural foodways offers a pathway for enhancing dietary diversity, cultural resilience, and locally grounded food sovereignty in borderland contexts.

Keywords
indigenous vegetables, Dayak Bidayuh, borderland food systems, food sovereignty, traditional ecological knowledge, household food security

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Introduction
Indigenous food systems are increasingly recognized as critical for sustaining food security, health, and cultural continuity among rural and frontier communities globally. Traditional food systems, defined as locally sourced and culturally embedded food practices, often encompass a diverse array of wild and cultivated plant foods managed through time-tested ecological knowledge and social norms (Kuhnlein et al., 2013; Sustainable Food Systems, 2022). At the same time, contemporary food systems across Southeast Asia face increasing inefficiencies along agricultural value chains. Post-harvest stages alone may account for up to 75% of total food value-chain costs, and food losses in Indonesia have been estimated at approximately 20% of total agricultural production (Garrity et al., 2024).

The border region of West Kalimantan is characterized by considerable ethnic diversity, and the persistence or transformation of Indigenous food practices is shaped less by ethnic identity than by structural factors within the local food system. In particular, land access, intergenerational transmission of ecological knowledge, and increasing exposure to cross-border market foods play decisive roles in shaping household food practices in the Entikong borderland. These dynamics highlight how Indigenous food systems are embedded within broader socioeconomic and territorial conditions rather than functioning solely as expressions of cultural identity.

Indigenous food systems and traditional ecological knowledge are increasingly recognized as important contributors to global sustainability agendas, including several Sustainable Development Goals related to food security, biodiversity conservation, and sustainable resource management (Nepal, 2025). Recent studies from the Asia-Pacific region have highlighted the need for collective action to preserve Indigenous food systems and to advocate for traditional food production through integrated approaches to food security, biodiversity conservation, and cultural heritage preservation. Indigenous food practices, such as harvesting traditional crops using nondestructive methods and utilizing knowledge and skills passed down through generations, have been shown by

scholars to be key components in sustaining resilient local systems of food production, nourishment, and ecological sustainability.

Across the Asia-Pacific region, scholars and practitioners have increasingly emphasized the importance of collective action to preserve Indigenous food systems and support traditional food production. These efforts often link food security, biodiversity conservation, and cultural heritage preservation. Indigenous food practices, such as harvesting traditional crops using nondestructive techniques and applying ecological knowledge transmitted across generations, play an essential role in sustaining resilient food systems, supporting ecological sustainability, and maintaining culturally meaningful diets.

Regional initiatives have therefore sought to strengthen traditional food production, expand market access for indigenous crops, and recover local ecological knowledge in response to pressures from modernization and dietary transitions. Such approaches highlight the importance of integrating community participation, supportive policy frameworks, and Indigenous knowledge in food governance. At the same time, regional analyses point to emerging challenges, including agricultural commercialization, forest loss, and changing consumption patterns, that threaten the continuity of traditional food practices and the intergenerational transmission of ecological knowledge.

These dynamics also highlight the need for empirical research that documents Indigenous food practices and explores how communities modify them in response to socioeconomic transformation. Research on Indigenous food systems can therefore usefully contribute to current debates about culturally appropriate and ecologically sustainable food strategies across Asia and the Pacific by positioning local case studies in a wider regional discussion.

Within this broader context, indigenous food sovereignty has increasingly been framed not only in terms of access to sufficient and nutritious food but also in communities' capacity to govern their food systems, protect customary knowledge, and maintain cultural identity amid environmental change and market integration (Sustainable Food Systems, 2022; World Bank, 2024). Yet the specific contributions of indigenous plant foods to household food security in borderland contexts such as the Indonesia–Malaysia frontier remain insufficiently explored.

Wild edible plants and indigenous vegetables are increasingly highlighted as nutrient-dense resources that enhance dietary diversity and strengthen resilience in local food systems. Evidence from studies in Asia and Africa suggests that wild and semidomesticated vegetables can significantly contribute to macro- and micronutrient intakes, particularly among low-income households facing periodic food shortages (Casas, 2024; Food and Agriculture Organization of the United Nations [FAO] et al., 2021; Hunter et al., 2021). Empirical work has also demonstrated that these plant foods serve as critical safety nets during economic and ecological shocks by supplementing staple foods and mitigating seasonal scarcity (Bliss et al., 2025; Kumar et al., 2025). Research on indigenous vegetables in Southeast Asia suggests that household production and use of these species may support both nutrition and livelihoods when integrated with culturally appropriate management practices (Hoang, 2025). However, most existing work in this region focuses on individual dimensions, such as nutrient composition or production systems, without simultaneously linking diversity, consumption patterns, and cultural perceptions within community food systems.

Household food insecurity and low dietary diversity persist as major challenges in rural Indonesia, where geographic remoteness, volatile food prices, and precarious livelihoods exacerbate vulnerability among smallholder households (Puspitasari et al., 2024; World Bank, 2024). Although Indonesia is classified as an upper-middle-income country, reflecting decades of economic growth and structural transformation, substantial regional inequalities in livelihoods and food access persist, particularly in frontier and rural borderland regions (Halimatussadiah et al., 2024). Studies conducted in Indonesian border areas indicate that limited market access, cross-border price asymmetries, and unstable supply chains increase household dependence on purchased foods, often with negative implications for dietary quality (Ariningsih et al., 2024).

At the same time, local natural resource use, especially the consumption of wild edible plants and indigenous vegetables, continues to play an important but underdocumented role in household diets in borderland settings. Research synthesizing food practices in frontier communities highlights the role of plant food knowledge transmitted through gendered and intergenerational networks (Sulaiman et al., 2024), yet robust quantitative data linking these practices to food security outcomes remain scarce. Studies from other contexts demonstrate that foraging practices persist even in urban environments. For instance, more than half of respondents engaged in foraging across multiple urban blue spaces in India, illustrating the continuing nutritional, cultural, and livelihood significance of these practices even in highly urbanized landscapes (Basu et al., 2025).

The Dayak communities of Borneo are widely recognized for their extensive ecological knowledge and diverse use of plant resources. However, most existing research has concentrated on shifting cultivation systems, staple crop production, or medicinal plant use rather than on indigenous vegetables and their contributions to household diets (Caviedes et al., 2024). Ethnographic research on Bidayuh culinary traditions in neighboring Sarawak highlights the cultural importance of locally foraged and cultivated plants in everyday meals and ritual contexts (Sageng et al., 2024), suggesting a rich but insufficiently documented diversity of edible species across the Indonesia–Malaysia border.

Civil society initiatives have also begun documenting traditional Dayak recipes and farming knowledge, reflecting growing interest in safeguarding Indigenous culinary heritage (Slow Food, 2025; Terralingua, 2024). These efforts are important for cultural preservation, and systematic academic research remains necessary to better understand the socioecological dynamics shaping these food systems. In particular, a significant gap persists in empirical studies that quantitatively link plant species diversity, consumption frequency, and nutritional contribution of indigenous vegetables to household food security outcomes among Dayak Bidayuh communities in Indonesian border regions.

In addition to their dietary importance, Dayak food traditions are closely intertwined with Indigenous knowledge of medicinal plants. Ethnobotanical studies have documented dozens of species used for therapeutic purposes, commonly prepared through boiling, infusion, or grinding of leaves, rhizomes, and roots (Haeruddin et al., 2017). This knowledge, transmitted across generations, reflects deep connections between forest biodiversity and Indigenous health systems in Borneo (Az-Zahra et al., 2021; Luardini et al., 2019; Qamariah et al., 2020). Historically, many indigenous Bornean communities have combined forest foraging, small-scale cultivation, and locally gathered food plants to meet household dietary needs. Indigenous livelihoods in the interior regions of Borneo have long depended on diverse forest resources, including hunting, fishing, and collecting of forest products for subsistence and trade (Jessup & Vayda, 1988). These practices not only provide nutritional diversity but also reinforce cultural identities linked to local landscapes and ecological knowledge (Murhaini & Achmadi, 2021). Even amid market integration and modernization, traditional diets remain closely connected to forest biodiversity, as documented in contemporary ethnographic and ecological studies.

To address these gaps, we examined how indigenous vegetables used by Dayak Bidayuh households in Entikong, West Kalimantan, contribute to household food security by integrating species inventories, consumption patterns, nutrient profiles, and community perspectives on access, cultural meaning, and change over time.

Beyond its cultural and ecological dimensions, the Bidayuh food system represents a localized model of borderland food provisioning that intersects with household nutrition, informal trade, and cross-border market dynamics. In this context, indigenous vegetables function not only as cultural foods but also as practical components of a community-based food economy shaped by land access, seasonality, and shifting dietary preferences. Understanding these dynamics offers practical insights for food system practitioners concerned with nutrition-sensitive agriculture, local food market development, and biodiversity-based food strategies.

This study documents Indigenous foraging, cultivation, and culinary practices within the Dayak Bidayuh community of Entikong, a borderland region where traditional food systems coexist with expanding market forces. Using household interviews, participant observation, foraging walks, and nutritional analysis, we investigated how knowledge of forest foods, farming practices, and culinary preparation has been maintained across generations. Particular attention was given to generational perspectives, as younger participants reveal emerging shifts in crop utilization, food preparation, and dietary preferences associated with modernization and livelihood diversification. By situating these practices within a broader socioeconomic context, the study provides empirical evidence for discussions on rural food system development and highlights the importance of documenting and supporting Indigenous food practices to sustain cultural heritage and local food security in borderland communities.

This case study, therefore, offers empirical insights that can inform policy initiatives and applied programs aimed at strengthening rural food systems, particularly in marginalized and borderland regions.

Dayak Bidayuh Identity

Among the Indigenous peoples of Borneo, the Dayak Bidayuh are a culturally and ecologically distinct group living primarily along the borderlands of West Kalimantan (Indonesia) and Sarawak (Malaysia). The term "Bidayuh," derived from the root *bi* ("land") and *dayuh* ("people"), historically referred to upland swidden cultivators whose lifeways were closely tied to forest mosaics, riverine systems, and shifting cultivation landscapes (Azmi et al., 2017; Seran & Mardawani, 2020). Unlike externally imposed ethnic categories, Bidayuh social identity has traditionally been rooted in microterritorial affiliation to particular *kampung* (villages) and river valleys rather than a singular pan-Bidayuh construct, leading to a rich tapestry of dialects, customs, and resource regimes within what outsiders label a single ethnolinguistic group (Azmi et al., 2017; Chua, 2009). In the Indonesian context, Dayak Bidayuh communities are often subsumed under broader "Dayak" classifications in census and development planning, a framing that obscures localized ecological knowledge and adaptive strategies embedded within borderland social systems (Chua, 2009; Pawi & Ungang, 2021).

Ecological knowledge and subsistence practices among the Dayak Bidayuh are deeply intertwined with sociocultural norms governing land use, seasonal mobility, and the management of plant resources. Traditional subsistence is characterized by shifting cultivation, rotational gardening, and diversified foraging strategies, which create spatial and temporal niches for a wide variety of edible plants, including leafy vegetables, tubers, and wild greens (Kumar et al., 2025; Sageng et al., 2024). This knowledge system extends beyond mere utility, encompassing the classification of species by ecological indicators, seasons, and sensory attributes. The system is transmitted through kinship networks and ritual calendars, making plant foods symbols of identity and continuity (Kumar et al., 2025; Sada et al., 2019). Such embedded practices are not static; they mediate the community's relationship with forest landscapes and serve as a cushion against seasonal scarcity and socioeconomic change.

The socioeconomic landscape of Bidayuh borderland communities has become increasingly hybridized due to market integration, cross-border mobility, and infrastructural development. Economic ties with Malaysian markets shape dietary patterns through access to commercially processed foods and wage labor, even as local plant foods remain central to household diets and cultural events (Kumar et al., 2025; Murhani, 2021). This dual economy, part market-oriented, part subsistence-based, generates both opportunities and tensions for Dayak Bidayuh families, influencing their food choices, the transmission of generational knowledge, and their resilience (Ting et al, 2017). Younger generations, exposed to formal schooling and external labor markets, are less engaged in traditional gardening and foraging, posing risks to the continuity of ecological knowledge that underpins Indigenous food systems (Murhaini & Achmadi, 2021).

Despite these pressures, many Dayak Bidayuh households in West Kalimantan actively maintain Indigenous food practices as a means of cultural

affirmation and nutritional sustenance. Locally harvested vegetables, leafy greens, and wild edible plants are not merely fallback options during lean seasons but are instead integrated into daily meals and ceremonial feasts, reinforcing a sense of belonging and ecological attachment (Kumar et al., 2025; Pawi, 2021; Sageng et al., 2024). Understanding Dayak Bidayuh food systems thus requires attention to the intersection of identity, territory, and ecological knowledge in a borderland context where state classifications, market forces, and cultural resilience coalesce. This ethnographic grounding provides critical context for examining how indigenous vegetables, and the knowledge systems that sustain them, contribute to household food security in Entikong and similar frontier settings.

Applied Research Methods

This research was grounded in ethical engagement and collaborative knowledge production with Dayak Bidayuh households in the borderland region of Entikong, West Kalimantan. West Kalimantan is located on the island of Borneo in western Indonesia and shares a land border with the Malaysian state of Sarawak; the province's location within Indonesia is shown in Figure 1. Figures 2 and 3 show the study area in Entikong Subdistrict. West Kalimantan is one of the most ethnically diverse provinces in Indonesia, with populations including Dayak, Malay, Javanese, Chinese, and several other ethnic groups (Ananta et al., 2015). This broader diversity characterizes the regional demographic landscape, but the present study focused specifically on Dayak Bidayuh households in the Entikong borderland community.

The research was conducted in five villages in Entikong Subdistrict, Sanggau District, West Kalimantan, a border region adjacent to Sarawak, Malaysia. Entikong Subdistrict has an estimated population of approximately 20,334 residents distributed across several rural villages characterized by smallholder farming, cross-border trade, and forest-based livelihoods (Badan Pusat Statistik Kabupaten Sanggau, 2023).

The study contributes to emerging work on indigenous food systems by centering Bidayuh knowledge, practices, and aspirations regarding indigenous vegetables and their role in culturally embedded, ecologically adaptive food systems. The aim was to document the diversity, dietary uses, and nutritional contributions of indigenous vegetables while examining how food knowledge is transmitted across generations amid socioecological change. To achieve this, we worked closely with local counterparts, village leaders, and community members who acted as cultural brokers, translators, and facilitators of trust (Davis & Brown, 2024).

In addition to purposive selection of key informants, snowball sampling was used to identify additional participants with relevant knowledge of

Figure 1. Geographic Location of West Kalimantan in Indonesia

Source: Natural Earth (2025). Map created and modified by the authors using QGIS.

Figure 2. The Study Area in Entikong Subdistrict, Sanggau District, West Kalimantan, Indonesia

Source: Base map from OpenStreetMap contributors (2025). Visualization and highlighting of study villages by the authors.

indigenous vegetables, foraging practices, and traditional food preparation. Snowball sampling is a nonprobability recruitment technique in which initial participants recommend other individuals within their social networks who meet the study criteria, making it particularly useful for accessing specialized knowledge holders or community members engaged in specific cultural practices (Gierczyk et al., 2023; Handcock et al, 2011). This approach enabled the research team to reach individuals who continue to practice foraging, gardening, and traditional culinary preparation within the Bidayuh community, thereby enriching the study's diversity of perspectives.

Initial access to Dayak Bidayuh settlements was established through academic collaborators and local health workers with longstanding relationships in the communities. The research also aimed to understand how indigenous plant species intersect with food insecurity, malnutrition, and biodiversity decline in border settings, as well as how cultural meanings and symbolic, seasonal, and medicinal aspects shape food preferences and uses.

An exploratory phase identified suitable villages and refined the research focus on ecological knowledge and intergenerational food practices. Access was negotiated through introductions by village heads (*kepala dusun*) and elders, who guided preliminary mapping of social structures, household networks, and subsistence activities. A participatory approach was adopted to reduce social distance, clarify research objectives, and ensure that community voices informed methodological decisions (Kurniawan et al., 2024).

Following this phase, five villages were selected using a multisite strategy to capture variation in ecological access and market exposure (Figure 3). Entikong and Semanget were classified as accessible border villages with strong exposure to Malaysian markets and processed foods. Nekan was situated at the forest fringe, blending foraging, gardening, and periodic market trips. Suruh Tembawang and Pala Pasang were remote villages accessible only via small roads or footpaths, with high dependence on forest foods and swidden agriculture. This multisite village-selection strategy, designed to capture variation in ecological access, market exposure, and settlement accessibility, provided comparative insight into how settlement geography shapes food practices, ranging from predominantly foraging-based diets to hybrid diets increasingly influenced by cross-border commodities.

Key informants were initially identified using

Figure 3. Map of Study Villages in the Entikong Border Area, Sanggau District, West Kalimantan, Indonesia

Source: Base map from OpenStreetMap contributors (2024). Village boundaries and visual annotations were created and modified by the authors.

purposive (expert) sampling, selecting individuals recognized within the community for their knowledge of indigenous vegetables, plant identification, seasonal harvesting cycles, and traditional food preparation practices. Purposive or expert sampling is commonly used in qualitative and community-based research to identify "information-rich" participants with specialized knowledge relevant to the phenomenon under study (Patton, 2018). To broaden participation and reach additional knowledgeable individuals, snowball sampling was subsequently employed, whereby initial informants recommended other community members actively engaged in foraging, gardening, or gathering indigenous vegetables. Snowball sampling enables researchers to access social networks of expertise and is particularly useful for identifying participants involved in culturally embedded practices that may not be easily identifiable through conventional sampling frames (Ahmed, 2024).

Key informants included men and women aged 30–75 years who were widely recognized within the community for their expertise in plant identification, seasonal cycles, and traditional food

preparation. As key informants are intended to provide specialized knowledge rather than represent the broader population, a second group of non-key informants was included to reflect the community's general demographic characteristics. These respondents were primarily younger adults aged 18–30 years, who were less directly engaged in traditional subsistence activities but offered insights into contemporary dietary preferences and the growing influence of market-based food systems. This inclusion is particularly relevant given Indonesia's relatively young demographic structure, with a national median age of approximately 30 (Population Pyramids, 2024). The distinction between key informants and non-key informants, therefore, enabled the study to compare traditional knowledge holders with younger community members whose food consumption patterns reflect ongoing socioeconomic and dietary transitions.

Data were collected from June to October 2025 through semi-structured interviews, household surveys, foraging walks, foraging observations, and participant observation. Similar participatory field approaches have been widely applied in community-based research to better understand everyday practices and lived experiences within local environments, particularly when investigating culturally embedded activities such as food gathering and resource use (Yeo et al., 2024). Semi-structured interviews documented plant names, edible parts, harvesting sites, seasonal availability, preparation methods, consumption frequency, and associated meanings. Ambulatory interviews during walks to gardens, forest edges, and riverbanks enabled participants to contextualize plants in situ and explain ecological indicators and harvesting practices. Nutritional analyses were conducted on selected species using laboratory assessment of macro- and micronutrients. All plant images presented in this study were documented by the authors during fieldwork and were used to support species identification and local naming practices.

Data analysis combined qualitative and quantitative techniques. Interview transcripts were manually transcribed and coded using an inductive thematic analysis approach to identify recurring patterns related to plant knowledge, cultural identity, and food security (Clarke & Braun, 2017). Initial codes were generated from the interview data and subsequently grouped into broader thematic categories reflecting knowledge transmission, food practices, and perceptions of dietary change. Household survey data on consumption frequency were converted into dietary frequency tables to summarize patterns of indigenous vegetable use among respondents. Laboratory nutrient analyses were integrated into household nutrient profiles to estimate the potential contribution of selected indigenous vegetables to dietary intake. Cross-site comparisons were then conducted to assess how ecological access, market proximity, and generational differences influenced both knowledge and consumption patterns. The household questionnaire and interview guide are provided in Appendix A. A structured household questionnaire was used to document food sources, indigenous vegetable consumption, foraging practices, processed food consumption, and cross-border food market interactions. A sample of the questionnaire is presented in Appendix B. The reporting of qualitative methods and findings follows the Consolidated Criteria for Reporting Qualitative Research (COREQ) guidelines, with the checklist provided in Appendix C.

Our positionality as non-Bidayuh researchers shaped both field interactions and interpretation. Following Indigenous research methodologies that emphasize relational accountability and reflexivity (Gantley, 2018), we approached fieldwork as facilitators rather than as information extractors. Throughout the research, we prioritized community consent, privacy, and collaborative interpretation, aligning with broader principles of Indigenous self-determination in research. Ethical approval for this study was granted by the Ethics Committee on Social Studies and Humanities, National Research and Innovation Agency (BRIN), Indonesia (No. 027/KE.01/SK/01/2025). Informed consent was obtained from all participants prior to data collection.

Use of AI-Assisted Analytical Tools

In addition to manual coding and thematic synthesis, AI-assisted tools were employed to support data organization and writing. ChatGPT (OpenAI) was used as an auxiliary analytical tool

to assist in text summarization, reorganize preliminary codes into thematic clusters, and improve clarity during drafting. AI output was treated as supportive rather than authoritative, with interpretive decisions grounded in field data and community input.

Results

A total of 30 respondents from five Dayak Bidayuh villages, Entikong, Semanget, Nekan, Pala Pasang, and Suruh Tembawang, participated in this study, representing a diverse cross-section of age groups, gender roles, and socioeconomic activities (Table 1). Respondents ranged in age from 34 to 73 and included farmers, hunters, traders, teachers, health workers, midwives, and craftswomen. This variation reflects the multiscalar nature of food heritage in Bidayuh communities, where knowledge is produced and transmitted through various practices, including farming, foraging, household cooking, ritual practices, handicrafts, and market exchange.

Older male respondents commonly held roles associated with ritual food practices, ecological memory, and oral history, whereas female respondents were often engaged in household cooking, food preservation, nutrition, and the transmission

Table 1. Characteristics of Informants by Village

No.	Village	Gender	Age	Occupation	Role in Food Heritage
1	Entikong	Male	67	Farmer	Ritual food practices
2	Entikong	Female	57	Homemaker	Traditional cooking
3	Entikong	Male	45	Community youth leader	Transmission of food culture
4	Entikong	Female	34	Teacher	School-based food knowledge
5	Entikong	Male	60	Trader	Local market food exchange
6	Entikong	Female	50	Weaver	Food-linked handicrafts
7	Semanget	Male	73	Retired farmer	Oral historian
8	Semanget	Female	52	Homemaker	Culinary knowledge
9	Semanget	Male	41	Hunter	Wild food gathering
10	Semanget	Female	39	Farmer's wife	Household cooking
11	Semanget	Male	64	Village elder	Ceremonial food practices
12	Semanget	Female	48	Midwife	Nutrition and healing foods
13	Nekan	Male	62	Farmer and hunter	Food gathering
14	Nekan	Female	47	Community health worker	Nutrition practices
15	Nekan	Male	35	Youth farmer	Adoption of modern crops
16	Nekan	Female	55	Homemaker	Preservation of daily meals
17	Nekan	Male	70	Retired trader	Oral memory of markets
18	Nekan	Female	42	Craftswoman	Linking crafts with foods
19	Pala Pasang	Male	57	Farmer	Rice cultivation
20	Pala Pasang	Female	62	Homemaker	Preservation methods
21	Pala Pasang	Male	38	Hunter	Protein source (game meat)
22	Pala Pasang	Female	36	Teacher	Passing on food knowledge
23	Pala Pasang	Male	66	Village elder	Ritual food custodian
24	Pala Pasang	Female	49	Farmer's wife	Household cooking knowledge
25	Suruh Tembawang	Male	52	Small-scale livestock rearer	Protein sources
26	Suruh Tembawang	Female	67	Homemaker and artisan	Fermentation methods
27	Suruh Tembawang	Male	44	Farmer	Mixed farming food sources
28	Suruh Tembawang	Female	59	Weaver	Food-related crafts
29	Suruh Tembawang	Male	61	Community elder	Custodian of traditional diet
30	Suruh Tembawang	Female	40	Young mother	Everyday child nutrition

of artisanal knowledge. Participants from the younger age group within the sample (mid-30s to mid-40s), including both men and women, contributed perspectives on shifting practices, the adoption of modern crop varieties, and evolving dietary preferences influenced by market integration. Collectively, this respondent profile enabled the study to capture both specialist knowledge and everyday food practices across generations and settlement types.

From the interview transcripts, participant observation, and multi-site comparisons, five interrelated themes emerged: (1) hybrid livelihood and cash-based dependency, (2) dietary transitions and the role of border markets, (3) cultural significance of indigenous dishes, (4) erosion of ecological knowledge and intergenerational gaps, and (5) gendered constraints in food provisioning (Figure 4). These themes illuminate how Dayak Bidayuh households negotiate cultural food heritage within an increasingly modernized borderland economy.

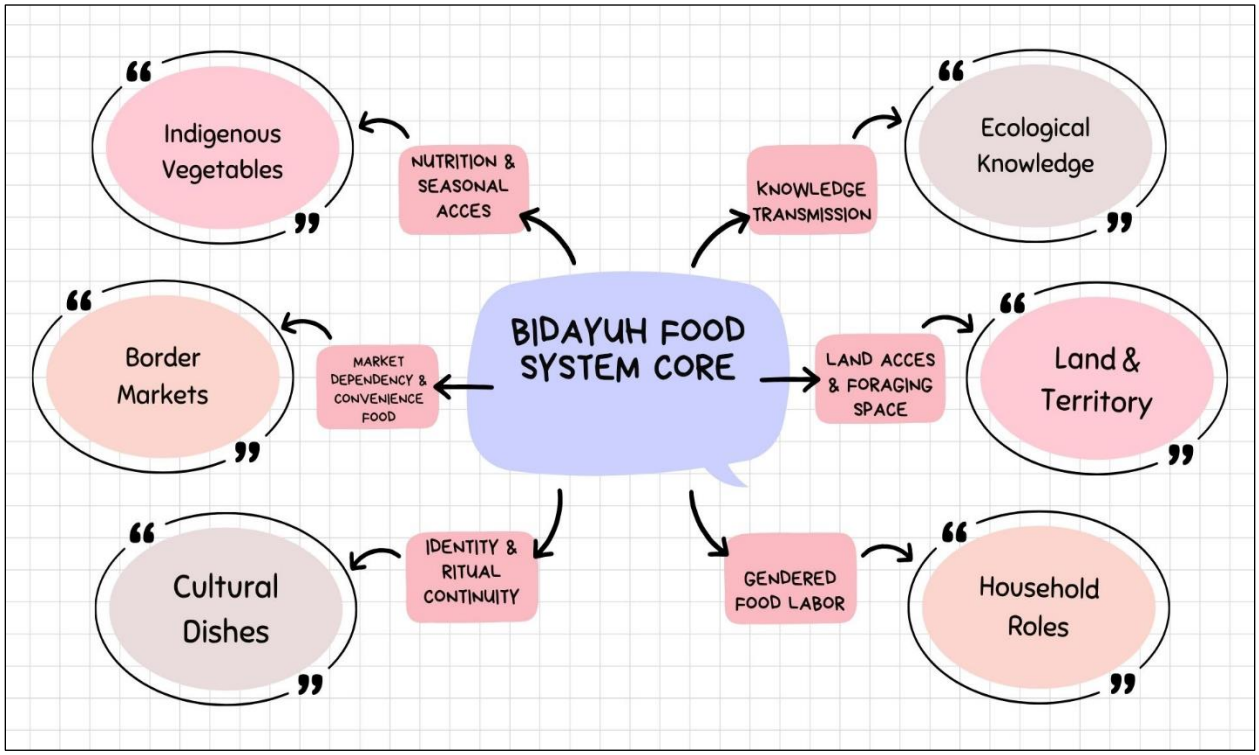
Hybrid Livelihood and Cash-Based Dependency

Despite changing practices, subsistence agriculture and foraging remain elements of the local food system; most households now integrate wage labor, cross-border trading, and seasonal commodity sales into their livelihoods. Data from interviews suggest that increasing dependence on Malaysian markets has reshaped local food economies, with rice, instant noodles, processed snacks, and bottled beverages becoming everyday staples.

Several older participants noted that younger generations prioritize wage earnings over foraging, reducing wild foods within household diets. As one community elder explained at length:

> In the past, we did not talk much about buying food because everything we needed was nearby, rice from the *ladang*, vegetables from the forest, meat from hunting, or chickens we raised. But now it is different. Many of our young people work as drivers, porters, or trad-

Figure 4. Conceptual model of the Bidayuh Food System Core



Source: Developed by the authors based on thematic analysis of qualitative data using NVivo.

> ers, or cross the border to Malaysia to find daily wages. When they come home in the evening, there is no time to go to the forest. So the wife buys cabbage, carrots, or instant noodles from the shop. It is faster. But it also means our food depends on money and prices, not just on seasons or our knowledge. When the border was closed during COVID, we really felt how much we have changed because people found it difficult to buy food. Some of us went back to the forest for bamboo shoots and leaves. As you can see, we now depend on both worlds. (Informant 17, Male, 70 years old, Nekan)

This statement illustrates how hybrid economies create both flexibility and vulnerability, particularly during border disruptions, seasonal shortages, and price fluctuations.

Dietary Transitions and the Role of Border Markets

The increased availability of commercial vegetables and processed foods, especially from markets in Tebedu and Serian (Sarawak), has altered cooking practices. In more accessible villages, indigenous vegetables account for an estimated 10–15% of weekly household vegetable intake, compared to 30–40% in forest-fringe settlements. Purchased foods now fill dietary gaps that were historically supplied by wild greens and tubers.

One middle-aged female respondent described the impact of border markets on everyday meals in detail:

> Before the big shops came, our cooking was mostly what we found or planted such as *pucuk paku* (edible fern shoots), *daun ubi* (cassava leaves), bamboo shoots, and whatever fruits or mushrooms we could collect. Even chicken was only for special days. However, it is now normal to buy chicken from the freezer and sometimes vegetables from the market in Malaysia. If my daughter calls me from Serian and asks what I want, I say cabbage or carrots because they are cheap there. For wild vegetables, I still cook them when I have time or when older relatives visit, because they miss the taste. However, young people in Tebedu or Entikong prefer fast food. They say it is easier and more modern. So, our kitchen reflects the border. We mix our heritage with whatever we can buy on the other side. (Informant 8, Female, 52 years old, Semanget)

This shift suggests not only dietary diversification but also a reconfiguration of cultural value, convenience, and identity.

Cultural Significance of Bidayuh Dishes

Despite rapid dietary modernization, several indigenous dishes continue to play a central role in Dayak Bidayuh identity, ritual life, and collective social gatherings. These dishes are deeply embedded in cultural memory and rely on indigenous vegetables, forest herbs, and traditional preparation techniques that reinforce connections to land and community. *Sayur rampai* represents a good example of this continuity. It is prepared from a mixture of wild or garden leaves, such as *pucuk ubi* (cassava shoots), *daun kucai (*garlic chives), *daun bawang bukit* (wild mountain onion/ wild chives), and bamboo shoots, often cooked together with coconut milk and occasionally dried fish. The dish embodies both culinary diversity and the ecological knowledge required to identify and collect seasonal leafy vegetables. The preparation of mixed wild greens also reflects a broader culinary tradition found in many cultures, where foraged leafy plants are cooked together as part of everyday diets and seasonal food practices. Comparable traditions include the preparation of wild greens dishes in the southern United States, South Asian *saag*, and mixed Asian leafy vegetable dishes, all of which highlight the cultural importance of gathering and cooking diverse local greens as expressions of regional food heritage (Cook Me Indonesian, 2022; The Intrepid Eater, 2023; Wild Greens and Sardines, 2020).

Pekasam is a traditional fermented fish product widely found in Indonesia and Malaysia, produced through spontaneous fermentation involving lactic acid bacteria that contribute to its distinctive sour flavor and preservation properties (Mahyudin et al., 2015). Meanwhile, *ayam pansuh*, chicken cooked in bamboo with forest herbs such as *bawang hutan*

(wild shallots), *serai* (lemongrass), and *daun bungkang*, a local forest herb, remains closely associated with harvest rituals and communal celebrations. Beyond flavor, the dish encodes values of respect for the forest, cooperation, and ceremonial reciprocity. Together, these dishes illustrate how Bidayuh foodways are not only nutritional systems but cultural technologies that sustain identity, intergenerational knowledge, and social cohesion in the borderland context. During fieldwork in Suruh Tembawang, women emphasized that these dishes are markers of identity:

> *Ayam pansuh* (bamboo-cooked chicken) is not just food; it is how we celebrate family, guests, and big days. When people come from Pontianak or Kuching, we cook pansuh as a sign of respect. The herbs come from the forest, and only certain people know which leaves to use. If you use the wrong leaves, the taste will be weak or bitter. *Sayur rampai* is everyday food. We mix whatever leaves we have. *Pek-asam* is food for difficult times because it lasts a long time. These foods teach our children who they are, even if they go far away later. (Informant 28, Female, 59 years old, Suruh Tembawang).

Such culinary practices sustain continuity between ecological knowledge, social ties, and identity within the Bidayuh community. At the same time, Indonesian cuisine more broadly has gained international recognition through widely published cookbooks that introduce regional dishes and culinary traditions to global audiences, including works such as *Indonesian Cooking: Satays, Sambals and More* by Dina Yuen, *Mortar and Pestle: Classic Indonesian Recipes for the Modern Kitchen* by Patricia Tanumihardja, and *Coconut & Sambal: Recipes from My Indonesian Kitchen* by Lara Lee.

Erosion of Ecological Knowledge and Intergenerational Gaps

Interviews revealed substantial generational differences in knowledge of edible species, harvesting grounds, and ecological signals (e.g., the emergence of bamboo shoots after rain). Elders could identify 20–30 edible plant species with detailed harvesting instructions; however, many younger respondents could identify fewer than five, usually limited to *pucuk ubi* (cassava shoots), *daun singkong* (cassava leaves), and *pucuk paku* (fern shoots).

A retired farmer described his concerns at length:

> When I was younger, my father took me to the forest almost every week. He taught me how to recognize plants, how to smell the leaves, and how to determine if the shoots were edible. Now, children do not follow us to the forest. They follow the school schedule, the handphone, and the internet. If we ask them to join, they say it is tiring or there are mosquitoes. I am worried because knowledge is not written in books; it is in our memory. If no one learns it, it will disappear. Then one day our grandchildren will see a wild vegetable and not know if it is food or poison. (Informant 7, Male, 73 years old, Semanget)

This statement illustrates how ecological knowledge related to edible plants, such as cassava shoots, cassava leaves, and fern shoots is traditionally transmitted through direct participation in forest-based activities. As younger generations spend less time in farming and foraging environments, opportunities for experiential learning decline, contributing to the gradual erosion of traditional ecological knowledge within the community.

Role of Indigenous Vegetables in Household Food Security

Across all five villages, indigenous vegetables remain central to daily household food provisioning, functioning as both primary ingredients for routine meals and fallback foods during periods of cash shortages or market inaccessibility. Participants frequently emphasized the abundance and accessibility of leafy greens, edible shoots, gingers, ferns, and wild herbs found in swidden fields, home gardens, and forest edges. Species such as *pucuk ubi* (cassava shoots), *daun kucai* (garlic chives), *daun bawang bukit* (wild mountain onion/wild chives), *rebung* (bamboo shoots), *kelakai* (edible fern/*Stenochlaena palustris*), *bawang hutan* (wild shallots/*Eleutherine bulbosa*), and wild gingers were con-

sistently mentioned as seasonal staples that help reduce dependence on purchased foods (Figures 5–10).

For many households, indigenous vegetables serve as a crucial buffer against nutritional and economic shortages. Several participants described how market-bought vegetables are often reserved for ceremonial events or when household finances allow, whereas indigenous vegetables are relied upon during "difficult weeks," especially when

Figure 5. *Pucuk Ubi* (Cassava Shoots)

Figure 6. *Daun Kucai* (Garlic Chives)

Figure 7. *Daun Bawang Bukit* (Wild Mountain Onion/Wild Chives)

Figure 8. *Rebung* (Bamboo Shoots)

Figure 9. *Kelakai* (Edible Fern/*Stenochlaena palustris*)

Figure 10. *Bawang Hutan* (Wild Shallots/ *Eleutherine bulbosa*)

Source: Photographs of indigenous vegetables documented during fieldwork by the authors, Entikong Sub-district, West Kalimantan, Indonesia, 2025

income is irregular or cross-border travel is restricted. One farmer explained that :

> When cash runs out, we don't panic because the vegetables around the village are always there. Tapioca shoots, ferns, wild garlic leaves, bamboo shoots, those foods never disappear. We sometimes buy vegetables from across the border, but when the weather is bad, or the checkpoint closes early, we return to what we call *sayur kampung* [traditional local vegetables]. My wife says these vegetables don't require money, only labor and knowledge. We grew up with them, so we know when bamboo shoots appear, when certain leaves turn bitter, and when their smell tells you they're good for cooking. That's why when the price of cooking oil increases or the market becomes too expensive, our meals continue. Border communities survive because we still have plants that don't come from shops. (Informant 19, Male, 57 years old, Pala Pasang)

Gendered Constraints and Time Burden

Food-related labor remains gendered, with women managing cooking, fermentation, and childcare, while men have historically hunted and gathered forest vegetables. However, modern wage labor and trade have reduced men's participation in forest activities, increasing women's time burdens or forcing households to substitute wild foods for purchased produce. Women in Suruh Tembawang and Pala Pasang reported foraging trips of 3–6 hours, compared to 1–2 hours in the past. A community health worker explained:

> To get *daun empasak* or bamboo shoots now, we must walk far, sometimes across old logging roads or up the hills. If I go alone, it takes half a day, and when I return, I still must cook, clean, and take care of the children. So sometimes I choose to buy vegetables from the market because it is easier. My mother-in-law says it tastes different, and she is right, but time is also important now. Women carry many responsibilities, and the forest does not wait for us as it did before. (Informant 14, Female, 47 years old, Nekan)

These shifts highlight how food transitions intersect with gender, labor, and ecological change.

Applied Relevance for Food System Development

The findings illustrate several entry points for strengthening local food systems. First, indigenous vegetables remain nutritionally relevant and seasonally available, offering a low-cost food source during periods when market foods are unaffordable or inaccessible. Second, cross-border markets create both opportunities and vulnerabilities: Households gain exposure to diverse food items and additional income streams, yet dependence on convenience foods may increase as fresh vegetables are replaced with processed imports. Cross-border mobility in Entikong is facilitated through special border travel permits such as the *Pas Lintas Batas* (PLB) and *Kartu Identitas Lintas Batas* (KILB), which allow residents of designated border areas to cross into Sarawak for small-scale trade and daily activities. This mobility can influence household food purchasing patterns and market access within the borderland food system. Third, intergenerational gaps in food knowledge indicate a fragile mechanism of knowledge transmission, suggesting that food system interventions must integrate cultural transmission alongside agricultural support. Fourth, land access continues to shape foraging practices and seasonal diets, making territorial access a food security issue rather than a purely cultural one.

Together, these insights offer actionable leverage points for community-based food system development rather than merely providing ethnographic description. The study area is also situated within the broader Brunei–Indonesia–Malaysia–Philippines East ASEAN Growth Area (BIMP-EAGA), a subregional cooperation initiative intended to stimulate economic development in peripheral regions through improved connectivity and cross-border trade. However, as noted in recent analyses, the benefits of these regional initiatives remain uneven across districts and rural communities.

Discussion

The BIMP-EAGA region is characterized by considerable ethnic diversity. Our findings suggest that

structural factors such as land access, generational knowledge transmission, and exposure to market food systems play a more decisive role than ethnicity alone in shaping the persistence or transformation of indigenous food practices in the Entikong borderland.

Building on the findings from semi-structured interviews, participatory observation, ecological mapping, and culinary ethnography, this study collaborated with Bidayuh key informants and household-level participants to co-develop a conceptual model of food heritage and food system resilience in the Indonesia–Malaysia borderlands. Rather than treating Indigenous food practices as static traditions, the model frames Bidayuh food knowledge as a dynamic system shaped by land access, ecological literacy, household labor, and cross-border market forces. Centering community voices helped ensure that the framework responds to local priorities, such as cultural food identity, access to forest vegetables, and dietary adaptation; nevertheless, it also acknowledges external pressures on Bidayuh diets, livelihoods, and cultural continuity (Ting et al., 2017; Utomo, 2021).

Food Heritage and Food System Dynamics

Bidayuh communities in Entikong have undergone rapid transformation due to infrastructure expansion, commercialization, and changes in land use. These shifts affect dietary composition, ecological knowledge transfer, and gendered labor in agriculture and foraging, patterns consistent with Indigenous food system transitions elsewhere in Southeast Asia (Ajibola et al., 2023; Casas et al., 2024; Tan et al., 2024). Reduced access to forest edges limits wild vegetable foraging, while the proliferation of border markets increases exposure to packaged foods, echoing findings among upland minorities facing state territorialization and pressures from commercial agriculture (Caviedes et al., 2024; Ege et al., 2022).

For the Bidayuh, food is inseparable from ancestral land (*tanah adat*), seasonal calendars, and ritual identity (Hartini, 2019; Widiyarto et al., 2020). The conceptual model developed here highlights six interconnected components: indigenous vegetables, ecological knowledge, land and territory, household roles, cultural dishes, and border markets, linked through mechanisms such as knowledge transmission, gendered labor, ritual continuity, and market dependency (Figure 10).

Territory, Self-Determination, and Identity

The findings align with broader arguments that food sovereignty is inseparable from territorial self-determination (Puspitasari et al., 2024; Seran & Mardawani, 2020). Land constitutes a cultural and epistemic space where food knowledge and identity are enacted (Simanjuntak & Erwinsyah, 2020). In border settings, territorial issues intensify due to overlapping jurisdictions, commodity flows, and limited recognition of customary land (Sulaiman et al., 2024). In addition, deforestation and land-use change in parts of Borneo have reduced access to forest resources that historically supported foraging and the collection of wild edible plants. Elders' statements that "without land, there is no forest, and without forest, there is no food" mirror Indigenous food movements globally (Suswandari et al., 2022; Tamang, 2010). Even without the strong legal advocacy platforms seen in other Indigenous contexts, cultural self-determination through food, the maintenance of ritual dishes, seed exchanges, and customary slaughter functions as an everyday form of sovereignty within fragmented governance structures (Casas et al., 2024; Firdaus et al., 2019).

Border Markets and Economic Adaptation

The Entikong–Tebedu border corridor illustrates a classic cross-border food economy. Households frequently reported relying on Malaysian processed foods due to their affordability and convenience. The reports reflect regional trends in which imported, energy-dense processed foods, such as instant noodles, packaged snack foods, sweetened beverages, and processed meat products, displace traditional diets (Li J., 2022; Miranda, 2022; Ting, H., 2017). This creates market dependence and lowers incentives to forage, especially among youth.

However, border markets are not purely extractive. Bidayuh farmers also sell bamboo shoots, vegetables, and fruits across the border, forming micro-value chains similar to Indigenous trade systems in Sarawak, Sabah, and Kalimantan

(Chua, 2009; Ege et al., 2022; H. Li et al., 2024). Thus, border economies simultaneously erode and enable Indigenous food systems, depending on how value chains are structured.

Cultural Food Heritage and Knowledge Transmission

Bidayuh dishes such as ayam pansuh, sayur rampai, and pekasam encode ecological adaptation, seasonal availability, and ritual significance. Similar to other Indigenous contexts, communal meals reinforce social cohesion and moral economies (Harmayani et al., 2019; Ray, 2015). Interviews reveal that older women are the primary custodians of culinary knowledge, aligning with the existing literature on the gendered nature of food knowledge transmission (Chinea et al., 2020; Minton et al., 2019). Youth disinterest and urban migration threaten this process, mirroring Indigenous cases in Taiwan, Canada, and Malaysia, where schooling and digital media are eroding ecological literacy (Abdul, 2017; Hong, 2025; Jiménez- Moreno et al., 2023). Revitalization strategies such as festivals, food education, and intergenerational cooking may bolster cultural resilience.

Nutrition Transitions and Health

Dietary transitions among Bidayuh households reflect a broader nutritional transition toward refined carbohydrates, sugars, and oils, thereby heightening the risks of noncommunicable diseases (Hu, 2011; J. Li et al., 2022). Elders reported favoring foraged vegetables and home-cooked foods; however, youth preferred instant noodles and sugary drinks, patterns consistent with Hunter et al.'s (2021) nutrition transition model. Meanwhile, forest vegetables like ferns, bamboo shoots, and leafy greens contain micronutrients and antioxidants (Hunter et al., 2021; Utomo, 2021). Preserving indigenous vegetables therefore, represents both a cultural and public health strategy aligned with Indigenous food sovereignty arguments for metabolic and cultural well-being (Hu, 2011; J. Li et al., 2022).

Biodiversity, Ecological Knowledge, and Sustainable Development

Bidayuh ecological knowledge constitutes a form of traditional ecological knowledge (TEK) that directly shapes how biodiversity is accessed, managed, and sustained within local food systems. This knowledge system encompasses plant identification, seasonal harvesting cycles, and culturally embedded norms of resource use, such as selective harvesting, rotation of foraging sites, and minimal extraction of key species (Astutik et al., 2018; Azmi et al., 2017; Rusliyadi et al., 2019). In practical terms, TEK functions as an informal management system that regulates human–environment interactions and supports the long-term availability of indigenous vegetables (Sageng et al., 2024; Sanggin et al., 2016). However, as this study indicates, reduced access to forest areas and declining participation of younger generations in subsistence activities are weakening the transmission of this knowledge, creating risks not only for cultural continuity but also for biodiversity-dependent food systems (Hunter et al., 2021; Utomo & Widjaja, 2021).

These findings clarify the relevance of TEK within broader sustainability frameworks, particularly its contribution to multiple Sustainable Development Goals (SDGs). The use of indigenous vegetables supports SDG 2 (Zero Hunger) by enhancing dietary diversity and local food availability, while sustainable harvesting practices align with the principles of SDG 12 (Responsible Consumption and Production). At the same time, the reliance on forest biodiversity and the maintenance of ecological knowledge systems are closely linked to SDG 15 (Life on Land). They are also indirectly linked to SDG 13 (Climate Action) through the preservation of resilient, low-input food systems (FAO et al., 2021; Nepal, 2025). By explicitly linking TEK to these outcomes, this study demonstrates that Indigenous food practices are not only culturally significant but also function as locally grounded strategies for biodiversity conservation and sustainable development in borderland contexts.

Ethical Space and Collaborative Knowledge Production

Indigenous research methodologies emphasize an ethical space in which Indigenous and academic worldviews coexist without hierarchy (Hartini &

Fusnika, 2019; Hoang et al., 2026). This study adopted an approach that allowed participants to define food priorities and ecological relationships using Bidayuh categories, rather than Western abstractions. Ethical collaboration prevents knowledge from being fragmented into "scientific pieces" detached from cultural and cosmological systems (Kuhnlein et al., 2013; Macours, 2019; Widiyarto et al., 2020). For food system work, ethical space enhances community legitimacy and cultural fidelity.

Scalability and Practitioner Implications

Nevertheless, the Bidayuh model is context-specific; it is conceptually transferable if adapted to border dynamics, customary land tenure, gendered labor, and culinary identity. Similar polycentric approaches are also evident in other Indigenous food sovereignty initiatives (Rozaki, 2020; Widiyarto, 2022; Yuslie et al., 2021). Strengthening Bidayuh food systems is therefore not only a cultural exercise but also a strategy for dietary diversification, biodiversity conservation, and economic resilience in border settings.

Limitations

Certain procedures recommended in the COREQ checklist were not implemented in this study. Repeat interviews were not conducted because the research design relied on single-session interviews combined with participant observation and field notes to capture participants' perspectives. Returning transcripts to participants for correction was also not feasible due to logistical constraints and the dispersed nature of households in the border villages. Similarly, formal member checking was not conducted; however, findings were triangulated through multiple data sources, including interviews, participant observation, and cross-site comparisons across villages. These approaches were used to enhance the credibility and consistency of the qualitative analysis, respecting the practical constraints of fieldwork in remote border communities.

Recommendations and Future Research

The findings suggest several practical directions for strengthening Indigenous food systems in border regions such as Entikong. One potential pathway involves the development of managed foraging programs, where communities, local governments, and universities collaborate to document edible plant species, establish sustainable harvesting guidelines, and integrate ecological monitoring. Such initiatives could help preserve TEK and ensure that forest resources are used responsibly.

A second opportunity lies in strengthening micro–value chains for Indigenous vegetables and forest foods, enabling local producers to market traditional products, such as bamboo shoots and seasonal greens, through community markets or cross-border trade networks. At the same time, youth-oriented knowledge transmission programs, including school-based ecological education and community food festivals, could help bridge generational gaps in ecological knowledge. Future research could examine how these initiatives can be implemented through partnerships among universities, local governments, and Indigenous communities, particularly in borderland contexts where food systems are shaped by both ecological and cross-border economic dynamics.

Conclusion

Our findings demonstrate that in Entikong, food sovereignty continues to be anchored in households' daily consumption of indigenous vegetables within Dayak Bidayuh communities and emphasize their importance as a safety net for household food systems during economic shocks, limited market access, or both. These locally available plant resources continue to play an important role in maintaining dietary diversity and building a resilient hybrid food system through subsistence-oriented practices alongside the cash economy, despite increasing reliance on cross-border markets and on processed foods. But these systems are beleaguered. The loss of traditional ecological knowledge that sustains Indigenous food systems is being catalyzed by factors such as rapid dietary shifts, diminishing participation of younger generations in foraging and agriculture, and blanket restrictions on forest products.

The results clearly show that we cannot think of Indigenous food systems simply as frozen cultural artifacts, but instead have to see them as

dynamic systems continuously changing through land access, labor patterns, gender roles, and market integration. To strengthen these systems, there is an urgent need for tailored and contextualized interventions that include securing access to customary land, intergenerational transfer of knowledge, and establishment of local value chains for indigenous vegetables. It has been argued that this gradual loss of ecological knowledge will, in turn, led to a greater dependence on the external food system and eventually threaten both long-term food security and cultural continuity without such interventions. Within this context, maintaining indigenous vegetables is not only a question of nutrition but rather a strategy to strengthen resilience and food sovereignty in borderland populations.

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Appendix A. Semi-Structured Interview Guide for Household and Key Informants

Section 1. Respondent Background

1. What is your age?
2. What is your gender?
3. What is your main occupation?
4. How long have you lived in this village?
5. What are your main sources of livelihood (e.g., farming, trading, wage labor, forest products)?

Section 2. Indigenous Vegetables and Foraging Practices

6. What types of indigenous vegetables or forest plants are commonly consumed in your household?
7. Where are these plants usually obtained (forest, farm, garden, market)?
8. Who in the household usually collects or prepares these vegetables?
9. Are there particular seasons when these plants are more abundant?
10. How do you identify which plants are safe to eat?

Section 3. Traditional Ecological Knowledge (TEK)

11. How did you learn about edible plants or vegetables in the forest or fields?
12. Who taught you these skills?
13. Are younger generations still learning how to identify and collect these plants?
14. Have you noticed changes in how people use or collect these plants over time?
15. Are there traditional rules or customs related to harvesting plants from the forest?

Section 4. Food Consumption and Dietary Changes

16. What foods are most commonly eaten in your household today?
17. Compared to the past, have eating habits changed in your community?
18. What kinds of processed or packaged foods are commonly consumed today?
19. Do younger people prefer different foods compared to older generations?
20. In your opinion, are traditional foods still important for health and culture?

Section 5. Cross-Border Markets and Food Access

21. Do households in this village buy food from markets across the border?
22. What kinds of foods are usually purchased from Malaysian markets?
23. Are these foods cheaper, more convenient, or preferred for other reasons?
24. Do households also sell vegetables, fruits, or forest products across the border?
25. How does cross-border trade affect local food availability?

Section 6. Land Access and Environmental Change

26. Where do households usually collect forest foods?
27. Has access to land or forest areas changed in recent years?
28. Have you noticed any changes in forest resources or plant availability?
29. What factors affect your ability to collect traditional foods today?
30. In your opinion, how important is land and forest access for maintaining traditional diets?

Section 7. Cultural Significance of Indigenous Foods

31. Are there traditional dishes that use indigenous vegetables?
32. When are these dishes usually prepared (daily meals, rituals, celebrations)?
33. Which dishes are considered culturally important in the community?
34. Do younger people still know how to cook these traditional foods?

Section 8. Future Perspectives

35. What challenges threaten the continuation of traditional food practices?
36. What could be done to preserve knowledge about indigenous vegetables?
37. Would programs such as community gardens, foraging training, or food festivals help maintain these traditions?
38. What role should government or universities play in supporting traditional food systems?

Appendix B. Household Survey Questionnaire

Section A. Household Characteristics

1. Age of respondent: _____
2. Gender:
   ☐ Male
   ☐ Female
3. Main occupation:
   ☐ Farmer
   ☐ Trader
   ☐ Wage labor
   ☐ Government employee
   ☐ Other: _____
4. Household size: _____ persons
5. How long has your household lived in this village?
   ☐ Less than 5 years
   ☐ 5–10 years
   ☐ More than 10 years
   ☐ Since birth

Section B. Food Sources

6. Where does your household usually obtain vegetables?
   ☐ Home garden
   ☐ Forest/foraging
   ☐ Local market
   ☐ Cross-border market (Malaysia)
   ☐ Purchased from traders
7. Which food sources are most important for your household? (Select up to three)
   ☐ Own farm production
   ☐ Forest foods
   ☐ Local markets
   ☐ Cross-border markets
   ☐ Packaged foods

Section C. Indigenous Vegetable Consumption

8. Which indigenous vegetables does your household consume? (Multiple answers possible)
9. ☐ Cassava leaves (*Manihot esculenta*)
   ☐ Fern shoots (*Diplazium esculentum*)
   ☐ Pumpkin leaves (*Cucurbita* spp.)
   ☐ Bamboo shoots (*Bambusa* spp.)
   ☐ Kelakai fern (*Stenochlaena palustris*)
   ☐ Other: _____

10. How often does your household consume indigenous vegetables?

Frequency	Response
Daily	☐
Several times per week	☐
Once per week	☐
Rarely	☐
Never	☐

Section D. Foraging Practices

11. Does your household collect edible plants from forests or fields?
    ☐ Yes
    ☐ No

    If yes:

    Who usually collects these plants?
    ☐ Adult men
    ☐ Adult women
    ☐ Elderly household members
    ☐ Children/youth
    ☐ Entire household

12. How often does your household collect forest foods?

Frequency	Response
Weekly	☐
Monthly	☐
Occasionally	☐
Rarely	☐

Section E. Processed Food Consumption

13. Which processed foods are commonly consumed in your household? (Multiple answers possible)
    ☐ Instant noodles
    ☐ Packaged snack foods
    ☐ Sweetened beverages
    ☐ Processed meat products
    ☐ Other: _____
14. How often are these foods consumed?

Frequency	Response
Daily	☐
Several times per week	☐
Occasionally	☐
Rarely	☐

Section F. Cross-Border Food Markets

15. Does your household purchase food from Malaysian markets?
    ☐ Yes
    ☐ No

If yes:

16. What foods are typically purchased across the border?
    ☐ Packaged foods
    ☐ Fresh vegetables
    ☐ Fruits
    ☐ Meat or fish
    ☐ Other: _____
17. Why does your household buy food across the border?
    ☐ Lower price
    ☐ Better availability
    ☐ Better quality
    ☐ Convenience
    ☐ Other: _____

Section G. Perceptions of Traditional Food Systems

18. Do you think traditional vegetables are important for household nutrition?
    ☐ Very important
    ☐ Important
    ☐ Not very important
    ☐ Not important
19. Are younger people still interested in traditional vegetables?
    ☐ Yes
    ☐ Somewhat
    ☐ No
20. What do you think is the biggest challenge for maintaining traditional food practices?
    ☐ Loss of land access
    ☐ Declining forest resources
    ☐ Changing food preferences
    ☐ Market dependence
    ☐ Other: _____

Appendix C

COREQ Checklist (Consolidated Criteria for Reporting Qualitative Research)

No.	Item	Description	Addressed in Manuscript
Domain 1: Research Team and Reflexivity			
1	Interviewer/facilitator	Interviews were conducted by the lead researcher with support from local research assistants familiar with the Bidayuh language and culture	Methods
2	Credentials	The lead researcher holds a background in public health and community-based research on food systems	Methods
3	Occupation	The researcher was affiliated with a university research team during the study	Methods
4	Gender	Interviews were conducted by a male researcher with support from male and female local assistants	Methods
5	Experience and training	The research team had prior experience in community-based qualitative research and ethnographic fieldwork	Methods
6	Relationship established	Initial contact with participants was facilitated through village leaders and community representatives	Methods
7	Participant knowledge of the interviewer	Participants were informed about the research objectives and the role of the researcher	Methods
8	Interviewer characteristics	The research team acknowledged the importance of cultural sensitivity when discussing Indigenous food practices	Methods
Domain 2: Study Design			
9	Methodological orientation	The study employed a qualitative approach combining semi-structured interviews, participant observation, and thematic analysis	Methods
10	Sampling	Purposive sampling was used to identify knowledgeable informants, followed by snowball sampling to recruit additional participants	Methods
11	Method of approach	Participants were approached through community leaders and personal referrals	Methods
12	Sample size	A total of 30 respondents participated in the interviews	Methods
13	Non-participation	No participants withdrew from the study after consent was obtained	Methods
14	Setting of data collection	Interviews were conducted in villages in the Entikong border region of West Kalimantan	Methods
15	Presence of non-participants	In some cases, family members were present during interviews in household settings	Methods
16	Description of sample	Participants included farmers, traders, teachers, health workers, and community elders	Results
17	Interview guide	Semi-structured interview questions explored indigenous vegetable use, food practices, and cross-border food trade	Appendix A
18	Repeat interviews	Repeat interviews were not conducted	Methods
19	Audio/visual recording	Interviews were recorded and supplemented with field notes	Methods
20	Field notes	Observational notes were taken during and after interviews	Methods
21	Duration	Interviews lasted approximately 30–60 minutes	Methods
22	Data saturation	Data collection continued until thematic saturation was reached	Methods
23	Transcripts returned	Transcripts were not returned to participants for correction	Methods

continued

Table C, continued

No.	Item	Description	Addressed in Manuscript
Domain 3: Analysis and Findings			
24	Number of data coders	Coding and thematic analysis were conducted by the lead researcher	Methods
25	Description of coding tree	Codes were developed inductively to identify themes related to food practices, ecological knowledge, and market dynamics	Methods
26	Derivation of themes	Themes emerged through inductive thematic analysis of interview transcripts and field observations	Methods
27	Software	Coding and analysis were conducted manually	Methods
28	Participant checking	Member checking was not conducted	Methods
29	Quotations presented	Participant quotations are presented in the results section to illustrate key themes	Results
30	Data and findings consistent	Findings presented in the results are consistent with the interview data	Results
31	Clarity of major themes	Major themes include cross-border food markets, dietary transitions, ecological knowledge erosion, and cultural food practices	Results
32	Clarity of minor themes	Minor themes include gender roles in food preparation and generational knowledge gaps	Results