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Vulnerability and Resilience of Small-Island Food Security Systems: A Study of the Kepulauan Seribu, Indonesia

Sudarmono[1,4*], Fandra Wijaya[2], Reiner Pehebeherot[3]

[1,2,3] Institut Pemerintahan Dalam Negeri (IPDN), Jatinangor, Indonesia
[4] Dept. of Marine Affairs, University of Rhode Island, United States of America

*Corresponding Author, E-mail: sudarmono@ipdn.ac.id

Abstract

Food security on small islands depends not only on local production but also on the capacity of food systems to maintain their functions amid biophysical constraints and external dependence. This study examines the vulnerability and resilience of the food system in the Kepulauan Seribu (Kepulauan Seribu) Administrative Regency, Indonesia, by analyzing the interconnections among food availability, access, utilization, and stability. The study employed a qualitative case study design on Pramuka Island and Panggang Island. The researchers collected data through field observations and in-depth interviews with ten purposively selected informants and analyzed the data thematically. The findings show that marine resources support protein availability and local livelihoods, while limited land and freshwater resources create dependence on external food supplies. Weather disruptions and constraints on maritime connectivity affect the continuity of food distribution, which in turn influences food availability, economic access, and household food choices. Adaptive capacities—including urban agriculture, aquaculture, seafood processing, livelihood diversification, and local institutions—enable communities to manage some of the consequences of these disruptions but do not eliminate structural vulnerabilities. This study introduces the concept of interdimensional transmission of vulnerability to explain how vulnerability is transmitted across the dimensions of food security. The findings suggest that strengthening small-island food system resilience requires a hybrid system that combines diversified local production, institutional capacity, and stable external connectivity and distribution.

Keywords: small-island food security, interdimensional transmission of vulnerability, food system resilience, food connectivity.

Abstrak

Ketahanan pangan pulau kecil tidak hanya ditentukan oleh produksi lokal, tetapi juga oleh kemampuan sistem mempertahankan fungsi pangan di tengah keterbatasan biofisik dan ketergantungan eksternal. Penelitian ini bertujuan menganalisis kerentanan dan resiliensi sistem pangan di Kabupaten Administrasi Kepulauan Seribu, Indonesia, melalui keterkaitan dimensi ketersediaan, akses, pemanfaatan, dan stabilitas. Penelitian menggunakan pendekatan kualitatif dengan desain studi kasus di Pulau Pramuka dan Pulau Panggang. Data diperoleh melalui observasi lapangan dan wawancara mendalam terhadap sepuluh informan yang dipilih secara purposif, kemudian dianalisis secara tematik. Hasil penelitian menunjukkan bahwa sumber daya laut menopang ketersediaan protein dan penghidupan, sedangkan keterbatasan lahan dan air tawar menciptakan ketergantungan terhadap pasokan eksternal. Gangguan cuaca dan konektivitas laut ditransmisikan melalui kontinuitas distribusi menuju ketersediaan, akses ekonomi, dan penyesuaian pilihan pangan rumah tangga. Kapasitas adaptif melalui pertanian perkotaan, akuakultur, pengolahan hasil laut, diversifikasi penghidupan, dan kelembagaan lokal mampu mengelola sebagian konsekuensi gangguan, tetapi belum menghilangkan kerentanan struktural. Penelitian ini merumuskan *interdimensional transmission of vulnerability* untuk menjelaskan mekanisme transmisi kerentanan antardimensi. Temuan ini mengimplikasikan bahwa resiliensi pulau kecil memerlukan sistem hibrida yang mengombinasikan diversifikasi produksi lokal, kapasitas kelembagaan, dan stabilitas konektivitas serta distribusi eksternal.

Kata Kunci: ketahanan pangan pulau kecil, transmisi kerentanan antardimensi, resiliensi sistem pangan, konektivitas pangan.

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INTRODUCTION

Food security depends not only on a region's capacity to produce food but also on the capacity of its food system to ensure that communities have sufficient, safe, nutritious, accessible, and sustainable food supplies (Alonso et al., 2018; Prosekov & Ivanova, 2018; Sheng et al., 2025). The Food and Agriculture Organization (FAO, 2006) conceptualizes food security through four interconnected dimensions: availability, access, utilization, and stability. Meeting only one of these dimensions cannot ensure sustainable food security. These challenges become more pronounced on small islands because limited productive land and freshwater resources, geographic isolation, high logistics costs, exposure to climate shocks, and dependence on external food supplies constrain their food systems. FAO (2025) reports that imports account for more than 80% of the food supply in many Small Island Developing States (SIDS), while transportation and infrastructure constraints increase distribution costs and make food systems more vulnerable to disruptions. These conditions demonstrate that analyses of food security on small islands must extend beyond local production capacity and examine how food systems maintain availability, access, and utilization amid various disruptions.

These vulnerabilities characterize the food system of the Kepulauan Seribu Administrative Regency, which forms part of the Special Capital Region of Jakarta (DKI Jakarta) but has geographical conditions that differ from those of Jakarta's five administrative cities. Limited arable land constrains local food production across the archipelago and makes communities in the Kepulauan Seribu dependent on food supplies from mainland Jakarta. The spatial separation among islands also makes maritime transportation the primary infrastructure for food distribution; consequently, limited connectivity and adverse weather can disrupt food supplies and affect food prices (Kabupaten Administrasi Kepulauan Seribu, 2026). BPS Kabupaten Kepulauan Seribu (2026) reports that agriculture, forestry, and fisheries remain important components of the regional economy, while the Provincial Government of DKI Jakarta identifies limited access to clean water and maritime transportation connectivity as two major development challenges in the Kepulauan Seribu (Badan Pusat Statistik Kabupaten Kepulauan Seribu, 2026; Kabupaten Administrasi Kepulauan Seribu, 2026). At the same time, local fisheries provide an important source of animal protein, but limited land-based food production leaves communities dependent on off-island supplies for some of their food needs. These conditions create an asymmetry within the food system: local production capacity supports the availability of marine food resources, whereas connectivity with mainland areas strongly determines the continuity of supplies for many other food commodities. Food access in the Kepulauan Seribu therefore depends not only on household economic capacity but also on the continuity of spatial connectivity and distribution. This structure allows disruptions in maritime transportation to propagate into disruptions in food availability, access, and prices, making insularity an integral component of food system vulnerability in the Kepulauan Seribu.

Vulnerabilities arising from geographical conditions and dependence on external distribution interact with households' economic capacity to obtain adequate and nutritious food. In 2025, 12.37% of the population in the Kepulauan Seribu Administrative Regency, or approximately 3,350 people, lived below the poverty line. This proportion was the highest among the administrative regencies and cities of DKI Jakarta and substantially exceeded the provincial poverty rate of 4.28%. During the same period, the poverty line in the Kepulauan Seribu reached IDR 801,734 per capita per month (Badan Pusat Statistik Kabupaten Kepulauan Seribu, 2025). These conditions demonstrate that analyses of food access must account for household economic capacity, particularly because dependence on external supplies makes food prices sensitive to distribution costs and disruptions. Vulnerability also affects the utilization dimension of food security. The 2024 Indonesian Nutritional Status Survey reported that 2.1% of children

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under five in the Kepulauan Seribu were severely stunted and 14.8% were stunted, based on the height-for-age index, resulting in an overall stunting prevalence of 16.9% (Kementerian Kesehatan Republik Indonesia, 2025). These data demonstrate that access to local sources of marine protein does not automatically ensure food and nutrition security. Food security in the Kepulauan Seribu therefore emerges from interactions among biophysical capacity, continuity of distribution, economic access, dietary quality, and the food system's capacity to maintain these functions during disruptions.

Research on food security has developed along three major trajectories. First, scholars conceptualize food security as a multidimensional construct that encompasses availability, access, utilization, and stability (FAO, 2006). In small-island contexts, limited land and freshwater resources, geographic isolation, dependence on external food supplies, and changing consumption patterns simultaneously shape food vulnerability (Atzori et al., 2024). Haynes et al. (2020) demonstrate that food acquisition sources relate to dietary quality, while Bhagtani et al. (2022) find that food sources and sociodemographic characteristics are associated with dietary patterns and food insecurity among small-island communities. This body of literature extends the analysis of food security beyond production by emphasizing relationships among its dimensions, but it does not adequately explain how disruptions in one dimension affect the others.

Second, researchers explain small-island food vulnerability as a structural consequence of insularity and resource constraints. Leunufna and Evans (2014) demonstrate the importance of conserving and utilizing local food resources on small islands in Maluku that face limited agricultural resources. Vulnerability becomes more complex when land and freshwater constraints interact with geographic isolation and dependence on external food supplies (Atzori et al., 2024). Such dependence also relates to changing consumption patterns and health risks (Guell et al., 2022), while climate change, import dependence, food insecurity, and nutritional problems create overlapping forms of vulnerability (Guell et al., 2024). This literature demonstrates that insularity shapes the relationships among production, distribution, consumption, and external dependence, but it does not fully explain how food systems respond and adapt to disruptions.

Third, researchers have increasingly focused on food system resilience and adaptive capacity. Tendall et al. (2015) define food system resilience as the capacity of a food system to maintain its functions when disruptions occur, while Béné (2020) emphasizes the relationships among shock characteristics, actors, response strategies, and the continuity of food security. On small islands, local food production (Bhagtani et al., 2022), inter-island connectivity, governance and collective action (Hassan et al., 2026), and supply diversification combined with technology-based domestic production (Teng, 2020) can strengthen resilience. This literature indicates that interactions among resources, actors, institutions, connectivity, and adaptive capacities generate resilience. However, existing research has not adequately explained the mechanisms that connect resilience capacities with the simultaneous continuity of food availability, access, utilization, and stability, particularly in small-island food systems embedded within subnational governance structures.

Although existing literature has examined the multidimensional nature of food security, the structural vulnerabilities of small islands, and food system resilience capacities, empirical, analytical, and theoretical gaps remain. Empirically, most small-island studies focus on Small Island Developing States as national units of analysis, while researchers have devoted considerably less attention to the dynamics of food systems in subnational archipelagic regions that are integrated into metropolitan areas. Analytically, previous studies tend to examine supply dependence, local production, consumption patterns, nutrition, and adaptive capacity as components of vulnerability or resilience, but they do not sufficiently explain how

a disruption in one component propagates across and affects other dimensions of food security. This gap also has a theoretical dimension. The FAO (2006) framework conceptualizes availability, access, utilization, and stability as dimensions that food systems must fulfill to achieve food security, whereas the food system resilience framework explains the capacity of a system to absorb, respond to, adapt to, and maintain its functions during disruptions (Tendall et al., 2015). Integrating these two perspectives can explain not only the condition of each food security dimension but also the mechanisms through which vulnerability propagates across dimensions and the capacity of food systems to maintain functional linkages among these dimensions during disruptions. The Kepulauan Seribu provide a strategically relevant context for examining these relationships because their insular geography directly intersects with their administrative and economic integration into metropolitan Jakarta.

Based on these gaps, this study aims to analyze the vulnerability and resilience of the food security system in a small-island region through a case study of the Kepulauan Seribu Administrative Regency. The analysis focuses on how biophysical characteristics, local production capacity, dependence on external supplies, economic access, food utilization, and distribution disruptions interact to shape the dynamics of the four dimensions of food security: availability, access, utilization, and stability. This study also identifies how communities and local institutions use their adaptive capacities to absorb, respond to, and adapt to disruptions while maintaining the continuity of food system functions. Through this focus, the study integrates a multidimensional analysis of food security with a food system resilience perspective in the context of a subnational small-island region.

This study argues that food security vulnerability in small-island regions stems not only from limited local production but also from interdependencies among biophysical conditions, local production, external supplies, transportation connectivity, and economic access. In food systems that depend heavily on external supplies, stability functions not only as one of the dimensions of food security identified by FAO (2006) but also as a linking mechanism through which disruptions in connectivity and distribution propagate across food availability, access, and utilization. This study conceptualizes this mechanism as interdimensional transmission of vulnerability, which refers to the process through which disruptions in stability propagate across food security dimensions and increase the vulnerability of the food system as a whole. However, this vulnerability does not operate deterministically because actors and institutions build resilience through their capacity to absorb, respond to, adapt to, and maintain system functions during disruptions (Béné, 2020; Tendall et al., 2015). On this basis, this study extends the food system resilience framework by conceptualizing resilience not only as the capacity of a system to withstand and recover from disruptions but also as its capacity to maintain functional linkages among food availability, access, utilization, and stability throughout processes of disruption and adaptation. This argument positions stability as a strategic mechanism for understanding and strengthening food system resilience in small-island regions.

RESEARCH METHODS

The study uses the small-island food security system as its unit of analysis and focuses on the relationships among biophysical conditions, local food production, external food supplies, distribution, economic access, food utilization, and the capacities of communities and institutions to respond to disruptions. The study was conducted in the Kepulauan Seribu Administrative Regency, with fieldwork concentrated on Pramuka Island and Panggang Island. The researchers selected these two locations because they represent complementary functions within the local food system. Pramuka Island serves as the administrative center of the regency and a hub for public services, whereas Panggang Island

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constitutes a densely inhabited area with active fisheries and intensive community activities. Administratively, both islands belong to Pulau Panggang Urban Village, which allowed the researchers to examine the food system within a single administrative unit while accounting for differences in socioeconomic characteristics and spatial functions.

The study employed a qualitative approach with a case study design. The researchers selected this design because small-island food security represents a contextual phenomenon shaped by interactions among geographical conditions, community activities, food distribution, institutions, and policies; therefore, the phenomenon cannot be clearly separated from the context in which it occurs. A case study allows researchers to investigate a contemporary phenomenon in depth by drawing on multiple sources of evidence while preserving the contextual characteristics of the case under investigation (Yin, 2018). The qualitative approach also enabled the researchers to capture actors' experiences, mechanisms of distribution disruption, adaptation strategies, and relationships among food system components that quantitative indicators cannot fully explain. Accordingly, the research design aimed not only to describe food security conditions but also to explain the mechanisms that generate vulnerability and resilience within the food system of the Kepulauan Seribu.

The study drew on both primary and secondary data. The researchers collected primary data from informants whom they purposively selected based on their positions, authority, experience, and involvement in the Kepulauan Seribu food system. Five institutional informants participated in the study: the Head of the Food Security, Marine Affairs, and Agriculture Sub-Agency (KPKP); the Head of the Food Security and Agriculture Section; the Head of the Marine Affairs and Fisheries Section; the Head of the North Kepulauan Seribu Subdistrict; and the Head of Pulau Panggang Urban Village. The study also involved five community informants comprising fishers and residents of Pramuka Island and Panggang Island to obtain community perspectives on food production, distribution, access, consumption, and responses to food-related disruptions. The researchers obtained secondary data from official statistics, policy documents, program reports, and government documents related to food security, fisheries, agriculture, socioeconomic conditions, nutrition, and development in the Kepulauan Seribu. The use of multiple data sources enabled the researchers to triangulate government perspectives, community experiences, field conditions, and documentary evidence.

The researchers collected data through in-depth interviews, field observations, and document analysis. They conducted semi-structured interviews using an interview guide that covered the four dimensions of food security—availability, access, utilization, and stability—as well as different types of disruptions, responses, and adaptive capacities within the food system. During field observations, the researchers examined urban agriculture and greenhouse practices, aquaculture and ornamental fish cultivation, seafood processing, and food receiving and distribution activities at local docks. Through document analysis, the researchers examined policies, government programs, statistical data, and other information that could corroborate or extend findings from the interviews and field observations. The researchers used these three data collection techniques complementarily to compare informants' accounts with observed practices and documentary evidence, thereby strengthening the credibility of the case interpretation.

The researchers analyzed the data interactively through data condensation, data display, and conclusion drawing and verification, following the analytical framework developed by Miles et al. (2014). They first coded and thematically organized data from interviews, observations, and documents to identify patterns of vulnerability, disruptions, responses, and adaptive capacities. They then used the four dimensions of food security—availability, access, utilization, and stability—as analytical categories to map

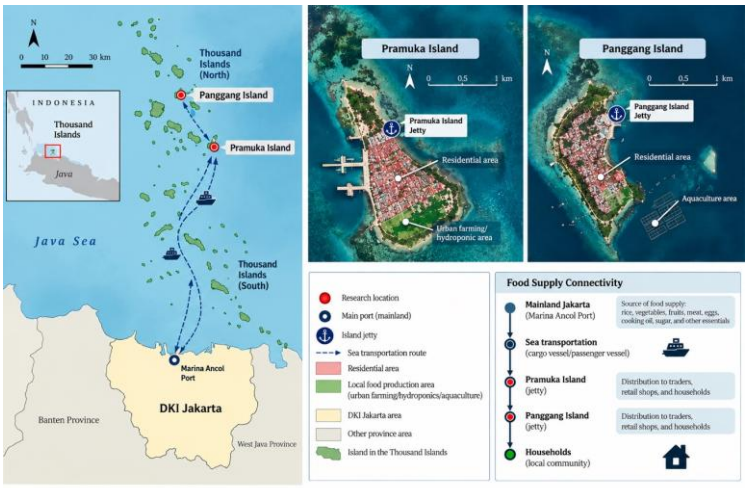
the conditions of the food system and applied a food system resilience perspective to examine the system's capacity to maintain its functions when disruptions occurred (Tendall et al., 2015). Rather than examining each analytical category in isolation, the researchers traced relationships across categories to identify how disruptions in distribution stability could propagate across food availability, access, and utilization and how communities and institutions responded to this process. Finally, the researchers conducted the interpretation iteratively by comparing findings across informants, field observations, and documentary evidence as a form of source triangulation before drawing the final conclusions.

RESULTS AND DISCUSSION

Structure and Vulnerability of the Kepulauan Seribu Food System

The region's biophysical characteristics shape the fundamental structure of the Kepulauan Seribu food system by creating an imbalance between marine-based and land-based food production capacities. Limited land area, productive land, freshwater availability, soil quality, and access to production media and inputs constrain the development of agriculture at a scale sufficient to meet community needs. The Head of the Food Security and Agriculture Section explained that land conditions, soil salinity and quality, water availability, and the need for seeds, fertilizers, and growing media constrain land-based food production capacity (MI, Head of the Food Security and Agriculture Section, interview, August 19, 2025). In contrast, the predominance of marine areas provides a stronger resource base for capture fisheries and aquaculture as sources of locally produced food. This pattern is evident on Pramuka Island and Panggang Island, where fisheries provide an important source of protein and support local livelihoods, while crop production remains limited to home gardens, hydroponics, and other forms of urban agriculture. Thus, biophysical conditions not only constrain the volume of local food production but also create an inherently asymmetric production structure: marine resources provide a relatively strong capacity to produce protein-rich foods, whereas terrestrial ecological constraints limit the region's capacity to produce adequate quantities of land-based foods.

Figure 1. Study Sites and Spatial Structure of the Food System



Source: Badan Informasi Geospasial (2025).

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The limited capacity for land-based food production contrasts sharply with the region's marine-based food production capacity. Capture fisheries and aquaculture constitute the primary foundations of local food production because they provide animal protein while supporting household livelihoods. The Head of the Marine Affairs and Fisheries Section explained that households consume some products from capture fisheries and aquaculture, trade some products locally, and market some outside the islands; the fisheries sector therefore performs both food and economic functions for local communities (BD, Head of the Marine Affairs and Fisheries Section, interview, August 25, 2025). Fishers also confirmed these dual functions at the household level. Families consume part of their catch and sell the remainder to generate income, which they then use to purchase rice, vegetables, fruit, cooking oil, eggs, and other foods that marine resources cannot provide (NK, fisher, interview, September 4, 2025). Locally available fish species include trevally, rabbitfish, grouper, and barramundi, demonstrating the diversity of protein sources available from local marine ecosystems (YU, fisher, interview, September 4, 2025). Fisheries therefore not only provide protein directly but also generate income that enables fishing households to purchase non-fish foods supplied from outside the islands. Marine resources consequently provide a relatively strong foundation for local food production, although they cannot replace the community's need for land-based food groups.

In contrast to the strong fisheries production base, land-based food production capacity in the Kepulauan Seribu remains limited in both volume and commodity diversity. Local crop production provides several types of vegetables and other crops, including bok choy, water spinach, mustard greens, lettuce, spinach, chili peppers, tomatoes, cucumbers, eggplants, bitter melon, corn, and melons, through home gardens, hydroponics, greenhouses, and urban farming. However, this production cannot meet the community's overall food needs. The Head of the Food Security and Agriculture Section explained that the islands continue to depend on mainland supplies for rice and most vegetables and fruit, as well as eggs, meat, cooking oil, sugar, and various processed foods (MI, Head of the Food Security and Agriculture Section, interview, August 19, 2025). Community experiences corroborate this account, as residents obtain rice, vegetables, fruit, eggs, cooking oil, and other daily necessities from local shops or traders who receive supplies from outside the islands (YU, fisher, interview, September 4, 2025; GG, resident, interview, September 5, 2025). Limited productive land, freshwater availability, soil salinity and quality, and dependence on seeds, fertilizers, and growing media primarily constrain local production. This structure empirically demonstrates the asymmetry of the food system: marine resources support relatively strong local production of animal protein, whereas staple foods and diverse land-based foods remain substantially dependent on external supply systems.

Amid the constraints on land-based food production, communities and local government agencies have developed urban farming, greenhouses, hydroponics, and home gardens as complementary forms of food production. Community groups and households primarily manage these activities by using available space and cultivation technologies suited to the islands' land constraints. On Pramuka Island, hydroponic systems produce bok choy, water spinach, mustard greens, lettuce, red spinach, tomatoes, chili peppers, and cucumbers, while cultivation at a broader scale also includes eggplants, bitter melon, corn, and melons. The Head of the Food Security and Agriculture Section explained that production remains limited in scale. For example, one cultivation activity managed by KWT Hijau Lestari on Pramuka Island produces approximately 15 kg of bok choy per harvest (MI, Head of the Food Security and Agriculture Section, interview, August 19, 2025). At the household level, residents reported that home gardens and urban farming help provide certain vegetables, but their production volume and diversity remain insufficient to meet daily consumption needs (GG, resident, interview, September 5, 2025). The urban village

government also reported that community groups participate in hydroponic cultivation and local vegetable production, although limited land, freshwater, production facilities, management capacity, and program continuity continue to constrain these activities (JS, Head of Pulau Panggang Urban Village, interview, August 27, 2025). Urban farming and local cultivation technologies have therefore expanded the sources of land-based food production in the Kepulauan Seribu, but they continue to play a complementary role and cannot replace food supplies from the mainland.

Figure 2. Local Food Production Practices on Pramuka Island and Panggang Island



(a) (b)

(a) Hydroponic vegetable cultivation by KWT Hijau Lestari on Pramuka Island; (b) fish aquaculture activities on Panggang Island.
Source: Kabupaten Administrasi Kepulauan Seribu (2023, 2024).

Limited local production directly connects the dietary diversity of communities on Pramuka Island and Panggang Island to supply systems originating from mainland Jakarta. Suppliers transport rice, most vegetables and fruit, cooking oil, eggs, meat, seasonings, and various other daily food necessities from outside the islands, while local production supplies fish and a limited quantity of vegetables. The Head of Pulau Panggang Urban Village explained that suppliers obtain some food supplies from Muara Angke Market and transport them to the islands by sea before agents, suppliers, local shops, and traders distribute them to residents (JS, Head of Pulau Panggang Urban Village, interview, August 27, 2025). Fishers similarly reported that ships transport rice, vegetables, fruit, cooking oil, eggs, and seasonings to the islands, after which households purchase these products from local shops or traders (YU, fisher, interview, September 4, 2025). The external food supply chain therefore operates through a distribution network that connects mainland supplier markets to maritime transportation, island docks, local agents or traders, retail shops, and ultimately households. This structure makes maritime connectivity a critical node because the continuity of nonlocal food supplies depends on the ability of vessels to connect mainland supply centers with island trading networks. The interview data did not consistently establish the frequency of food supply vessel arrivals; therefore, this study does not specify a particular distribution interval.

> "On Pramuka Island, residents generally obtain these necessities from local shops, vegetable vendors, or local agents and suppliers. These agents and traders obtain their goods from sources

that include Muara Angke Market and then transport them to the island. Therefore, although fish is locally available and small-scale vegetable production exists, households continue to depend heavily on mainland trade and transportation networks to meet their food needs." (JS, Head of Pulau Panggang Urban Village, interview, August 27, 2025)

Table 1. Structure of Food Sources and Distribution on Pramuka Island and Panggang Island

Food group	Primary source	Local production	Dependence on external supplies	Main distribution channel	Main vulnerabilities
Fish and seafood	Local waters	Predominantly produced through capture fisheries and aquaculture	Relatively low for meeting local fish demand	Fishers and aquaculture producers → local traders → households; some products are marketed outside the islands	Weather, waves, fishing seasons, operating costs, storage, and marketing
Rice	Mainland Jakarta	No substantial local production identified	Very high	Mainland markets/suppliers → maritime transportation → docks → agents, traders, or local shops → households	Maritime transportation disruptions, supply delays, stock availability, and prices
Vegetables	Local production and mainland supplies	Limited production through home gardens, urban farming, hydroponics, and greenhouses	High for meeting required volumes and diversity	Local production and mainland supplies → maritime transportation → traders or local shops → households	Limited land and freshwater, shelf life, distribution disruptions, and prices
Fruit	Primarily mainland sources	Very limited and does not constitute a major source for meeting local demand	High	Mainland supplies → maritime transportation → docks → traders or local shops → households	Distribution disruptions, shelf life, availability, and prices
Eggs and meat	Primarily mainland sources	No major local production source identified	High	Mainland supplies → maritime transportation → docks → traders or local shops → households	Dependence on maritime distribution, availability, and prices

Food group	Primary source	Local production	Dependence on external supplies	Main distribution channel	Main vulnerabilities
Cooking oil and sugar	Mainland sources	No local production identified	Very high	Mainland supplies → maritime transportation → docks → traders or distribution programs → households	Distribution disruptions, stock availability, and prices
Seasonings and other foods	Primarily mainland sources	Limited to several commodities, including chili peppers	High	Mainland supplies → maritime transportation → docks → agents, traders, or local shops → households	Distribution disruptions, limited stocks, and price fluctuations

Source: Authors' compilation based on interview and field observation data, 2025.

Dependence on mainland supplies makes household purchasing power a critical component of food access. Residents reported that staple foods generally remain available when distribution operates normally, although consumers have fewer choices for some commodities and face higher prices for certain products than consumers on the mainland because of additional costs and the length of maritime distribution chains (MO, resident, interview, September 7, 2025). Economic access becomes particularly vulnerable among households that depend on fisheries for their income. Fishers use income from selling their catch to purchase rice, vegetables, fruit, cooking oil, eggs, and other non-fish necessities (NK, fisher, interview, September 4, 2025). When catches or income decline, fishing households prioritize staple necessities, reduce the quantity or variety of certain foods they purchase, postpone other expenditures, or seek additional sources of income (SI, fisher, interview, September 7, 2025). These dynamics occur within a relatively vulnerable socioeconomic context. In 2025, 12.37% of the population of the Kepulauan Seribu Administrative Regency, or approximately 3,350 people, lived below the poverty line, which stood at IDR 801,734 per capita per month (Badan Pusat Statistik Kabupaten Kepulauan Seribu, 2025). These findings demonstrate that household food access depends not only on food availability in local markets but also on interactions among food prices, distribution costs, and households' economic capacity to purchase foods that largely originate outside the islands.

This production and access structure also shapes the food choices and dietary diversity available to households. Fish occupies a relatively strong position in local diets because households can obtain it from local fishers and traders, providing a source of protein without complete dependence on mainland supplies. However, locally available fish cannot replace rice, vegetables, fruit, cooking oil, and other food groups that households require (YU, fisher, interview, September 4, 2025). Vegetables from home gardens and urban farming also meet a portion of household needs, but their production volume and diversity remain insufficient for daily consumption (GG, resident, interview, September 5, 2025). When prices increase or certain commodities become difficult to obtain, residents reported reducing purchase quantities, choosing less expensive foods, substituting foods, postponing purchases, and using locally available food sources (GG, resident, interview, September 5, 2025). At the nutritional indicator level, the

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2024 Indonesian Nutritional Status Survey reported that 2.1% of children under five in the Kepulauan Seribu fell into the severely stunted category and 14.8% fell into the stunted category based on the height-for-age index, resulting in an overall stunting prevalence of 16.9% (Kementerian Kesehatan Republik Indonesia, 2025). These data do not establish a causal relationship between dependence on external supplies and stunting; rather, they provide contextual evidence that food utilization and dietary quality remain important dimensions for understanding food security conditions in the region.

The Kepulauan Seribu food system therefore exhibits an asymmetric structure. Marine resources provide a relatively strong foundation for local production through capture fisheries and aquaculture, whereas land-based food production meets only a limited share of community needs. Consequently, the islands continue to depend on mainland supply networks for rice, most vegetables and fruit, eggs, meat, cooking oil, sugar, and various other food necessities. This dependence extends beyond food availability because distribution costs and prices interact with households' economic capacity to obtain food, while limitations in the types and quantities of available foods shape household consumption choices. Food availability, access, and utilization within this archipelagic system therefore remain interconnected through supply continuity and maritime connectivity. This structure also indicates that disruptions to distribution connectivity can simultaneously alter conditions across multiple dimensions of food security, a mechanism analyzed further in the following section.

Distribution Disruptions and Interdimensional Transmission of Vulnerability Across Food Security Dimensions

Vulnerability in the Kepulauan Seribu food system primarily emerges when weather and marine conditions disrupt the maritime connectivity that supports food flows and fisheries production. Interviews revealed that strong winds, high waves, and unfavorable sea conditions can reduce or delay vessel operations, preventing food supplies from the mainland from arriving according to normal distribution patterns (LA, Head of the KPKP Sub-Agency, interview, August 12, 2025). At the same time, adverse weather also affects local food production because fishers may reduce or temporarily suspend fishing activities for safety reasons, which subsequently decreases catches and fishing household incomes (NK, fisher, interview, September 4, 2025). The Head of the Marine Affairs and Fisheries Section emphasized that weather and waves are not the only factors affecting fisheries production; fishing seasons, fishing grounds, operating costs, aquaculture conditions, transportation, cold-chain infrastructure, and marketing also influence production (BD, Head of the Marine Affairs and Fisheries Section, interview, August 25, 2025). These findings demonstrate that disruptions to the archipelagic food system do not originate from a single factor. Instead, a combination of meteorological pressures, marine conditions, seasonal factors, and connectivity constraints can simultaneously affect external supply flows and local food production. Interview data did not indicate a consistent frequency or duration of disruptions across informants; therefore, this study does not assign a specific intensity or temporal pattern to these disruptions.

Dependence on mainland supplies makes maritime connectivity a critical starting point in the emergence of food system disruptions in the Kepulauan Seribu. Under unfavorable weather and marine conditions, strong winds and waves can impede vessel operations or delay arrivals, preventing mainland food commodities from reaching the islands according to normal distribution patterns. The Head of the KPKP Sub-Agency explained that when vessel operations decrease or experience delays, commodities that depend on external supplies also arrive late, which can reduce stocks on the islands (LA, Head of the KPKP Sub-Agency, interview, August 12, 2025). The Head of the North Kepulauan Seribu Subdistrict described a similar pattern, explaining that wind and wave conditions that impede vessel operations can disrupt food

supplies because communities must obtain a substantial share of their food needs through maritime transportation (TI, Head of the North Kepulauan Seribu Subdistrict, interview, August 27, 2025). These findings demonstrate that maritime transportation serves not merely as a means of moving goods but as a critical node connecting mainland supply centers with food availability on the islands. When disruptions compromise this connecting function, meteorological disturbances that initially affect transportation become food distribution disruptions that directly affect the continuity of external supplies.

> "When adverse weather or high waves occur, fewer vessels may operate or their arrivals may be delayed. As a result, commodities that depend on supplies from outside the islands also arrive late, stocks decline, and prices may increase." (LA, Head of the KPKP Sub-Agency, interview, August 12, 2025).

Disruptions to maritime connectivity subsequently propagate to the food availability dimension by reducing the continuity of supplies originating from the mainland. When vessel operations experience delays, external supplies do not arrive according to normal distribution patterns, which can reduce stocks of several commodities on the islands (LA, Head of the KPKP Sub-Agency, interview, August 12, 2025). These effects do not occur uniformly across all food groups. Fresh commodities face greater vulnerability because they require more regular distribution and have shorter shelf lives; consequently, distribution delays affect the availability of vegetables and other fresh foods more rapidly than dry foods that households and retailers can store for longer periods (MI, Head of the Food Security and Agriculture Section, interview, August 19, 2025; MO, resident, interview, September 7, 2025). Under these conditions, locally sourced fish provides a buffer for household protein needs, but this function applies only to a specific food group and cannot replace rice, vegetables, fruit, cooking oil, and other non-fish commodities that largely originate outside the islands (YU, fisher, interview, September 4, 2025). Pressure on food availability therefore arises not primarily because all food sources cease production but because disruptions interrupt external commodity flows within a food system whose production structure lacks sufficient diversification to enable substitution across food groups. This finding demonstrates the first stage of interdimensional transmission of vulnerability: disruptions to the stability of maritime connectivity interrupt supply continuity and subsequently create pressure on food availability at the island level.

Pressure on food availability subsequently propagates to the access dimension when reduced or delayed supplies affect food prices and the range of foods that households can obtain. Community members reported that vessel delays cause goods to arrive later and reduce available stocks, particularly for commodities that depend on mainland supplies. Under these conditions, prices for several necessities, including chili peppers, rice, and cooking oil, may increase (YU, fisher, interview, September 4, 2025). The effects extend beyond price changes to a narrowing of consumption options. Residents explained that supply delays reduce the range of available foods, make fresh foods more difficult to obtain, and increase prices, prompting households to adjust their purchases by selecting commodities that remain available, reducing purchase quantities, substituting foods, or postponing certain purchases (GG, resident, interview, September 5, 2025). Fishing households experience greater sensitivity to pressures on food access because their capacity to purchase non-fish foods depends on income from their catches. When adverse weather simultaneously restricts fishing activities and food distribution, households may experience declining income while the availability and prices of food supplied from outside the islands also come under pressure (NK, fisher, interview, September 4, 2025). Supply disruptions therefore alter not only the quantity of food available on the islands but also households' ability to obtain food through changes in prices, income, and the range of purchasing options. This finding demonstrates the second stage of

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interdimensional transmission of vulnerability: supply interruptions create pressure on availability, which subsequently translates into pressure on household economic access.

> "When vessels are delayed, goods also arrive late and stocks in local shops become more limited. Products supplied from outside the islands are usually the most affected. Prices may also increase, for example, for chili peppers, rice, or cooking oil." (YU, fisher, interview, September 4, 2025).

Pressures on food availability and access subsequently affect household consumption choices. When disruptions affect distribution from the mainland, fresh commodities such as vegetables and fruit experience impacts more rapidly than foods with longer storage lives, thereby limiting household food choices (MO, resident, interview, September 7, 2025). Households respond by substituting foods, reducing purchase quantities, choosing less expensive foods, postponing certain purchases, and using available fish and other local foods (GG, resident, interview, September 5, 2025). Home gardens and urban farming help meet a portion of household food needs but cannot replace households' dependence on mainland supplies. These findings demonstrate that pressures on availability and access can propagate to the utilization dimension by narrowing food choices and prompting households to adjust their consumption. However, because this study did not measure nutrient intake or individual nutritional status, the analysis of this dimension remains limited to reported changes in food choices, substitution practices, purchase quantities, and dietary diversity.

Taken together, these findings demonstrate that food stability in the Kepulauan Seribu closely depends on the continuity of maritime connectivity and local production. When adverse weather, strong winds, and high waves disrupt vessel operations, the resulting pressure extends beyond transportation activities. Supply delays reduce the availability of certain commodities, particularly fresh foods. Changes in availability subsequently interact with price pressures and narrower purchasing options, prompting households to substitute foods, reduce purchase quantities, select less expensive alternatives, or postpone certain purchases. This pattern becomes more complex among fishing households because the same weather conditions can restrict fishing activities and reduce household income while simultaneously disrupting food distribution from the mainland (NK, fisher, interview, September 4, 2025). The data therefore demonstrate that stability does not operate independently from the other dimensions of food security. Disruptions to distribution and production continuity can propagate sequentially or simultaneously across food availability, economic access, and household food choices. Table 2 summarizes this empirical transmission pattern.

Table 2. Patterns of Disruption Transmission in the Kepulauan Seribu Food Security System

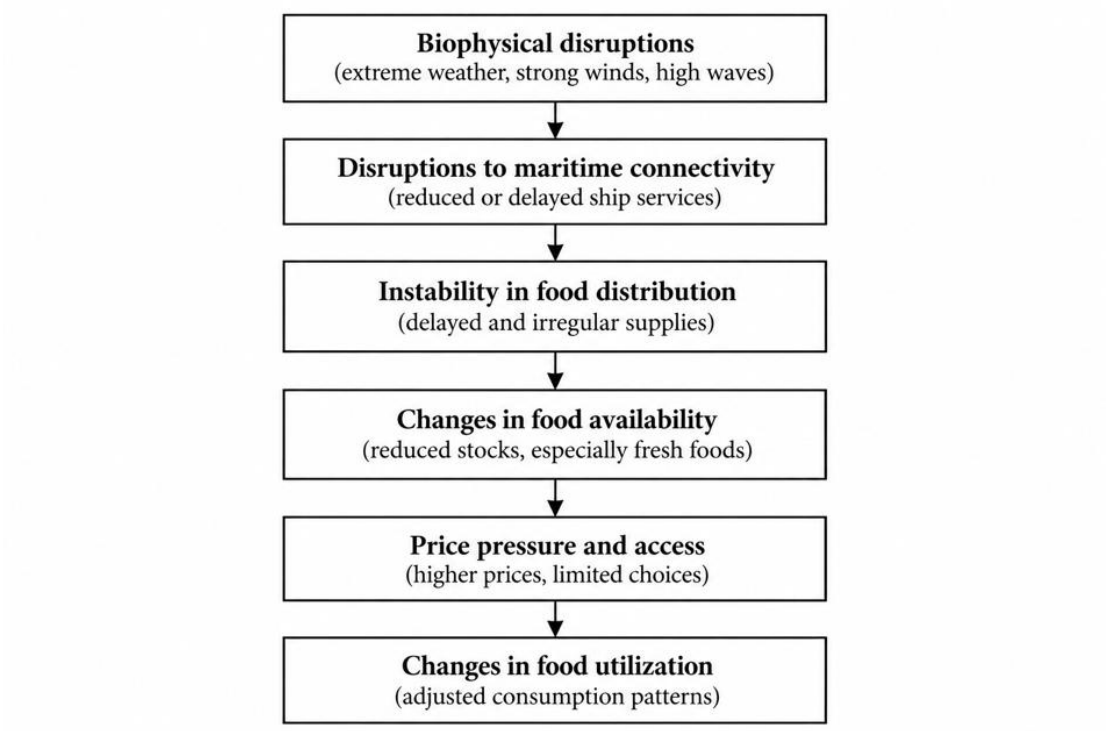
Initial disruption	Stability	Availability	Access	Utilization/consumption choices
Adverse weather, strong winds, and high waves disrupt vessel operations	Maritime transportation and the arrival of supplies become disrupted or delayed	Mainland food supplies arrive late, reducing stocks of some commodities	Prices for some commodities may increase, while purchasing options become more limited	Households substitute foods, reduce purchases, or select foods that remain available
Delays in the distribution of	The regularity of fresh food	Vegetables, fruit, and	Fresh food choices	Dietary diversity narrows, and households adjust the

Initial disruption	Stability	Availability	Access	Utilization/consumption choices
fresh commodities	supplies becomes disrupted	other short-shelf-life commodities experience impacts more rapidly than foods that can be stored for longer periods	become more limited, while price increases may constrain household purchases	types and quantities of food they purchase
Weather, waves, and seasonal factors restrict fisheries activities	The continuity of fishing activities and fish production fluctuates	Catches may decline, and production conditions affect local fish availability	Declining fisher income reduces households' capacity to purchase non-fish foods	Households prioritize staple foods, reduce the types or quantities of food they purchase, and use locally available foods
Adverse weather simultaneously restricts fishing activities and food transportation	Local production and external supply connectivity experience pressure at the same time	Fish catches decline while mainland food supplies arrive late or decrease	Fishing households face simultaneous pressures from declining income and potential food price increases or more limited food choices	Households adjust consumption by prioritizing staple foods, substituting foods, reducing purchases, and postponing certain expenditures

Source: Authors' compilation based on interview and field observation data, 2025.

The transmission of disruptions across food security dimensions varies according to food source, external dependence, shelf life, and the availability of local production. Local capture fisheries and aquaculture provide substantial support for fish availability, but weather, waves, seasonal conditions, and production factors continue to affect catches (BD, Head of the Marine Affairs and Fisheries Section, interview, August 25, 2025). In contrast, rice depends heavily on external supplies, which links its availability to the continuity of maritime distribution and existing stocks on the islands. Vegetables, fruit, and other fresh commodities display vulnerability more rapidly because of their short shelf lives, although home gardens, hydroponics, and urban farming provide limited local substitutes (MI, Head of the Food Security and Agriculture Section, interview, August 19, 2025; MO, resident, interview, September 7, 2025). Food vulnerability is therefore commodity-specific: external dependence and shelf life determine how rapidly pressure emerges when connectivity becomes disrupted, while local production can partially reduce sensitivity to these disruptions.

Figure 3. Mechanism of Interdimensional Vulnerability Transmission in the Kepulauan Seribu Food Security System



Source: Authors' analysis based on field research, 2025.

Overall, the findings demonstrate that vulnerability in the Kepulauan Seribu food system develops through a sequence of interconnected disruptions across food security dimensions. Biophysical disruptions involving weather, wind, and waves first affect maritime connectivity, subsequently interrupt the continuity of mainland food distribution, and place pressure on the availability of certain commodities at the island level. These pressures can then propagate through changes in prices and narrower purchasing options, ultimately affecting how households select, substitute, and adjust the quantities of food they consume. The intensity of this transmission varies according to commodity type and household livelihood source. Fresh foods that depend on external supplies show greater sensitivity to disruptions, while fishing households may experience simultaneous pressures from disrupted food distribution and declining income from fishing activities. This empirical pattern demonstrates how vulnerability in one part of the system can propagate to other parts through the interconnections among food stability, availability, access, and utilization.

Adaptive Capacity and Resilience of the Small-Island Food System

The findings further demonstrate that local communities and government agencies respond to food dependence and system disruptions through multiple strategies that perform different adaptive functions rather than through a single form of intervention. First, communities and local government agencies address constraints on land-based food production by expanding local food sources through urban

farming, hydroponics, greenhouses, and home gardens that produce several types of vegetables. Second, they strengthen the capacity of marine resources through capture fisheries, aquaculture, and seafood processing, which not only provide food but also sustain and diversify community income sources. Processing activities convert fish and other marine products into shredded tuna, salted fish, *pindang*, fish crackers, and seaweed-based products. Processing and marketing groups develop these products with support in the form of training and storage facilities, including freezers (BD, Head of the Marine Affairs and Fisheries Section, interview, August 25, 2025). Third, community groups and government interventions reinforce these responses by providing production facilities, training, aquaculture support, assistance for seafood processing, and food distribution facilitation (LA, Head of the KPKP Sub-Agency, interview, August 12, 2025; JS, Head of Pulau Panggang Urban Village, interview, August 27, 2025). At the household level, families also adapt by using savings, reducing expenditures, consuming available fish, seeking additional employment, and diversifying their economic activities when declining fisheries income places pressure on their primary livelihoods (NK, fisher, interview, September 4, 2025; SI, fisher, interview, September 7, 2025). Responses to food system vulnerability therefore operate simultaneously across several levels, including food production, household livelihoods, food processing, collective action, and institutional support. Together, these responses build local capacity to absorb and adapt to disruptions.

Communities and local government agencies promote diversification of land-based food production through home gardens, urban farming, hydroponics, and greenhouses in response to limited productive land. These practices produce various horticultural commodities, including leafy vegetables, chili peppers, tomatoes, cucumbers, eggplants, corn, and melons. On Pramuka Island, KWT Hijau Lestari produces approximately 15 kg of bok choy per harvest from two hydroponic racks (MI, Head of the Food Security and Agriculture Section, interview, August 19, 2025). This production expands local vegetable supplies, but its volume and diversity remain insufficient to meet the community's daily needs (GG, resident, interview, September 5, 2025). Limited land and freshwater, production inputs and growing media, costs, technology maintenance requirements, management capacity, and continuity of activities also constrain production capacity (MI, Head of the Food Security and Agriculture Section, interview, August 19, 2025; JS, Head of Pulau Panggang Urban Village, interview, August 27, 2025). Local production diversification therefore provides partial substitutes for several types of vegetables but has not substantially reduced the Kepulauan Seribu' dependence on mainland food supplies.

Unlike land-based food production, which remains limited, marine resources provide a stronger foundation for local production while supporting livelihood diversification. Capture fisheries and aquaculture contribute through two pathways: they provide protein and generate income that households use to purchase non-fish foods (BD, Head of the Marine Affairs and Fisheries Section, interview, August 25, 2025; NK, fisher, interview, September 4, 2025). Aquaculture and seafood processing expand this capacity by transforming marine products into shredded tuna, salted fish, *pindang*, fish crackers, and seaweed-based products, thereby increasing the value added to fisheries production. Aquaculture, processing activities, and supplementary employment also provide alternative income sources when catches fluctuate, although limited capital, equipment, storage capacity, skills, raw materials, marketing opportunities, and business continuity continue to constrain these activities (SI, fisher, interview, September 7, 2025). Marine resources therefore function not only as a source of locally produced food but also as adaptive assets that support food consumption, household income, and livelihood diversification in the face of production variability and dependence on external food supplies.

Seafood processing extends the adaptive functions of the fisheries sector by increasing value added, extending shelf life, and diversifying income sources. On Pramuka Island and Panggang Island, processing

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and marketing groups produce shredded tuna, salted fish, *pindang*, fish crackers, and seaweed-based products with support through training and storage facilities, including freezers (BD, Head of the Marine Affairs and Fisheries Section, interview, August 25, 2025). Processing allows producers to reduce their dependence on selling fisheries products exclusively in fresh form while providing alternative income opportunities when catches fluctuate (SI, fisher, interview, September 7, 2025). However, limited capital, equipment, storage capacity, skills, raw materials, marketing opportunities, and business continuity continue to constrain this capacity. Seafood processing therefore strengthens adaptive capacity by enabling more flexible use of fisheries production, increasing its economic value, and diversifying household income.

Interactions among local government agencies, community groups, and households also generate response capacity. The KPKP Sub-Agency monitors stocks and prices, coordinates distribution, and provides support for food production and related facilities (LA, Head of the KPKP Sub-Agency, interview, August 12, 2025). Meanwhile, subdistrict and urban village governments coordinate information, monitoring activities, supply interventions, and community activities at the local level (TI, Head of the North Kepulauan Seribu Subdistrict, interview, August 27, 2025; JS, Head of Pulau Panggang Urban Village, interview, August 27, 2025). These forms of institutional support connect with farmer groups, aquaculture groups, and processing and marketing groups that organize production, training, and the use of production facilities. This pattern demonstrates that adaptive capacity depends not only on household responses but also on the capacity of institutions to connect information, resources, coordination, and collective action when responding to food vulnerability.

> "Measures undertaken include urban farming, greenhouses, hydroponics, aquaculture, seafood processing, strengthening community groups, providing production facilities, and supporting distribution." (LA, Head of the KPKP Sub-Agency, interview, August 12, 2025).

Although communities and institutions have developed various adaptation strategies, biophysical, technical, economic, and institutional constraints continue to limit their capacity. Urban farming, hydroponics, and greenhouse-based production face constraints related to land, freshwater, production inputs, costs, technology maintenance, management capacity, and continuity of activities (MI, Head of the Food Security and Agriculture Section, interview, August 19, 2025; JS, Head of Pulau Panggang Urban Village, interview, August 27, 2025). Limited capital, equipment, storage capacity, skills, raw materials, marketing opportunities, and business continuity also constrain the diversification of fisheries enterprises and seafood processing (SI, fisher, interview, September 7, 2025). At the institutional level, coordination, data availability, administrative authority, transportation, budgets, and interagency dependence further constrain response capacity (TI, Head of the North Kepulauan Seribu Subdistrict, interview, August 27, 2025). The Kepulauan Seribu food system therefore possesses tangible but constrained adaptive capacity: local strategies expand production, livelihood options, and mechanisms for responding to disruptions, but they have not eliminated structural dependence on external supplies and connectivity.

Table 3. Adaptive Capacities of the Kepulauan Seribu Food System

Adaptive strategy	Primary actors	Vulnerability addressed	Food security dimensions strengthened	Main limitations
Urban farming and home gardens	Farmer groups, residents, local	Dependence on mainland	Availability, utilization	Production scale, land, freshwater,

Adaptive strategy	Primary actors	Vulnerability addressed	Food security dimensions strengthened	Main limitations
	government agencies	vegetable supplies		production inputs
Hydroponics and greenhouses	Community groups, KPKP Sub-Agency	Limited land and land-based food production	Availability	Costs, growing media, technology maintenance, management capacity
Aquaculture	Aquaculture producers, fisheries groups, KPKP Sub-Agency	Variability in fisheries production and livelihood dependence on capture fisheries	Availability, access	Capital, facilities, inputs, skills, continuity
Seafood processing	Processing and marketing groups, residents, KPKP Sub-Agency	Fluctuating fisheries production and dependence on selling fresh products	Availability, access	Equipment, storage, raw materials, marketing, capital
Household livelihood diversification	Fishers and households	Declining catches and household income	Access	Business opportunities, capital, skills, continuity of income
Strengthening community groups and institutional support	KPKP Sub-Agency, subdistrict government, urban village government, community groups	Limited production capacity and collective response capacity	Availability, access, stability	Coordination, data, budgets, authority, group capacity
Distribution monitoring and facilitation	KPKP Sub-Agency, subdistrict government, local government agencies	Supply disruptions and distribution instability	Stability, availability, access	Dependence on maritime transportation and interagency coordination

Source: Authors' compilation based on interview and field observation data, 2025.

Overall, the findings demonstrate that the adaptive capacity of the Kepulauan Seribu food system does not depend on a single strategy but emerges from a configuration of responses operating across production, livelihoods, processing, households, communities, and institutions. Urban farming, hydroponics, and greenhouses expand land-based food sources on a limited scale; capture fisheries and

aquaculture sustain the local protein supply and income base; seafood processing expands the utilization and economic value of fisheries products; and community groups and local government agencies provide knowledge, facilities, coordination, monitoring, and distribution support. However, these capacities have not eliminated constraints related to land and freshwater, dependence on production inputs, limited capital and technology, constraints on community group capacity, or dependence on maritime connectivity to meet most food needs. Adaptive capacity in the Kepulauan Seribu, therefore, operates primarily by expanding the range of available responses and maintaining specific food system functions under pressure, rather than by achieving complete food self-sufficiency. These findings provide the basis for assessing how adaptive capacities shape small-island food system resilience and how they interact with the interdimensional transmission of vulnerability identified in the preceding subsection.

DISCUSSION

The findings demonstrate that vulnerability in the Kepulauan Seribu food system emerges from the interaction among an asymmetric production structure, dependence on external connectivity, and limited local adaptive capacity. Marine resources provide protein and support community livelihoods, but the islands continue to rely on external supplies for most of their land-based foods. Within this structure, weather-related disruptions and disruptions to maritime connectivity extend beyond distribution problems, as changes in availability affect economic access and household food choices. At the same time, urban farming, aquaculture, seafood processing, livelihood diversification, and institutional support build capacity that enables communities to respond to some of these pressures, although these strategies cannot replace the structural dependence on mainland supplies. Small-island food vulnerability therefore does not arise solely from limited local production; rather, it emerges from interdependencies among production, distribution, access, consumption, and adaptive capacity that determine how the food system maintains its functions during disruptions.

This structure demonstrates that small-island food vulnerability stems not only from limited local production but also from insularity, which creates functional dependence on connectivity. Previous studies have identified limited land and freshwater resources, dependence on external supplies, and constraints on connectivity and distribution as important characteristics of small-island food system vulnerability (Atzori et al., 2024; Haynes et al., 2020; Kulke, 2023; Leunufna & Evans, 2014). The findings from the Kepulauan Seribu extend this understanding because, despite their integration into metropolitan Jakarta, the islands continue to depend on maritime connectivity between mainland supply centers and island distribution networks for many food necessities. Proximity to a major economic center therefore does not automatically reduce vulnerability when food supply continuity continues to depend on transportation systems that remain sensitive to weather and marine conditions. In this context, insularity represents not merely a geographical condition but a structure of dependence that shapes the system's capacity to maintain food supplies when connectivity becomes disrupted.

These findings clarify the relationships among the four dimensions of food security identified by FAO (2006): availability, access, utilization, and stability. In the Kepulauan Seribu food system, these dimensions do not operate independently. Weather-related disruptions affect maritime connectivity and distribution continuity, which subsequently place pressure on availability, affect prices and economic access, and prompt households to adjust their food choices. Among fishing households, this mechanism can create a dual burden because the same disruption can simultaneously constrain external supplies and reduce catches and household income. This study conceptualizes this pattern as interdimensional transmission of vulnerability, which refers to the process through which a disruption at one node of the

system propagates across other dimensions of food security through interdependencies among system components. This study therefore does not modify the four dimensions established by FAO; instead, it demonstrates that stability can function as a linking mechanism that affects the continuity of the other dimensions in small-island food systems that depend on external connectivity.

This transmission mechanism also demonstrates the importance of resilience as the capacity of a system to maintain food-related functions during disruptions. Tendall et al. (2015) conceptualize food system resilience as the capacity of a food system to maintain its functions, while Béné (2020) emphasizes the relationships among shocks, actors, response strategies, and the continuity of food security. The findings from the Kepulauan Seribu demonstrate that a configuration of complementary strategies generates this capacity: urban farming and hydroponics provide partial substitutes for land-based foods; fisheries and aquaculture support protein availability and household income; seafood processing expands the utilization and economic value of local production; and institutions connect knowledge, resources, coordination, and collective action. This pattern aligns with Ferguson et al. (2022), who demonstrate that local food production and food-sharing practices in coastal communities can strengthen the capacity to cope with shocks, while connections to external food sources continue to contribute to resilience. These strategies do not eliminate structural vulnerability, but they help communities absorb, reduce, and manage some of the consequences of disruptions. Small-island food system resilience can therefore be understood as a layered capacity to maintain food system functions and functional linkages among stability, availability, access, and utilization during disruptions.

These findings confirm previous research showing that resource constraints, dependence on external supplies, and interactions among local production, socioeconomic conditions, and consumption patterns shape small-island food vulnerability (Atzori et al., 2024; Bhagtani et al., 2022; Guell et al., 2021, 2024; Haynes et al., 2020). However, this study extends beyond identifying these factors by explaining the mechanism that connects structural vulnerability with resilience capacity. Structures of dependence determine the pathways through which connectivity disruptions propagate across food availability, access, and utilization, while configurations of adaptive capacity determine the extent to which the system can absorb and manage the consequences of these disruptions. The concept of interdimensional transmission of vulnerability therefore connects two analytical dimensions that previous research often treats separately: how vulnerability propagates through a food system and how adaptive capacities operate to maintain system functions. The study's contribution thus lies in explaining the relational dynamics among structures of dependence, interdimensional transmission of vulnerability, and adaptive capacity within small-island food systems.

However, adaptive capacity does not necessarily indicate food self-sufficiency or a fully resilient food system. In the Kepulauan Seribu, small production scales, limited land and freshwater resources, requirements for technology and production inputs, limited capital and marketing capacity, constraints on community groups, and discontinuities in programs restrict the capacity of local strategies to address structural vulnerabilities. This pattern aligns with Wairiu et al. (2022), who show that investment, technology, knowledge, and coordination constrain local food production in island regions, and with Atzori et al. (2024), who emphasize structural constraints related to land and freshwater resources. Guell et al. (2022) similarly demonstrate the value of local production for livelihoods and community resilience, while also showing that environmental pressures and dependence on purchased food continue to challenge its sustainability. Teng (2020), meanwhile, demonstrates that resource constraints require food systems to combine domestic production with diversified external supplies. As Béné (2020) cautions, the presence of adaptive strategies does not necessarily mean that a system has resolved the underlying sources of

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structural vulnerability. Resilience in the Kepulauan Seribu is therefore more appropriately understood as the capacity of a hybrid system that strengthens local production and institutions while maintaining stable external connectivity and distribution. This interpretation aligns with Hassan et al. (2026), who demonstrate the importance of multiscale connectivity, local actor capacity, governance, and collective action for island food system resilience.

The findings have theoretical implications for interpreting the four dimensions of food security established by FAO (2006) relationally, particularly in small-island food systems that depend on external connectivity. Analytically, the concept of interdimensional transmission of vulnerability demonstrates how disruptions to stability can propagate across availability, access, and utilization, while a resilience perspective explains the system's capacity to absorb and reduce the consequences of this transmission (Béné, 2020; Tendall et al., 2015). From a policy perspective, strengthening food security in the Kepulauan Seribu should focus not on achieving absolute local self-sufficiency but on developing a hybrid system that combines diversified local production, stable connectivity and distribution, stronger food reserves, seafood processing, institutional capacity, and collective action. Policy interventions should therefore extend beyond increasing production volumes and strengthen the food system's capacity to maintain the continuity of its functions during disruptions.

CONCLUSION

This study demonstrates that food security vulnerability in the Kepulauan Seribu emerges from interactions among biophysical constraints, an asymmetric production structure, dependence on external supplies, and maritime connectivity. Marine resources enhance protein availability and support community livelihoods, but limited productive land and freshwater resources mean most land-based foods depend on supplies from outside the islands. Within this structure, disruptions to weather conditions and maritime transportation can evolve from problems of distribution stability into pressures on food availability, economic access, and household food choices. Communities respond to these vulnerabilities through urban farming, hydroponics and greenhouses, aquaculture, seafood processing, livelihood diversification, and stronger institutional capacity. However, constraints related to production scale, land, water, production inputs, capital, technology, marketing, and institutional capacity limit these adaptive capacities. The findings therefore demonstrate that small-island food resilience does not require food self-sufficiency; rather, it depends on the food system's capacity to combine local capacities with stable external connectivity.

The scientific contribution of this study lies in its explanation of the dynamic relationships among structural vulnerability, disruption transmission, and adaptive capacity within a small-island food system. This study proposes the concept of interdimensional transmission of vulnerability to explain how disruptions to stability and connectivity propagate across food availability, access, and utilization via interdependencies among system components. This perspective extends the four dimensions of food security from categories analyzed separately toward a relational and dynamic understanding of their interactions. At the same time, the findings demonstrate that adaptive capacities do not necessarily eliminate the underlying sources of vulnerability but can absorb, reduce, and manage some of the consequences of disruptions, thereby enabling the food system to maintain its functions. Food resilience in the Kepulauan Seribu can therefore be more appropriately understood as a characteristic of a hybrid system that integrates diversified local production, a marine resource base, institutional capacity, and stable external connectivity and distribution.

This study has several limitations. It employed a qualitative case study of Pramuka Island and Panggang Island with a limited number of informants; therefore, the findings are not intended to support statistical generalization to all small-island regions. The study also did not quantitatively measure the magnitude, duration, or intensity of disruption transmission across food security dimensions or the relative effectiveness of each adaptive strategy in reducing its impacts. Future research could test the concept of interdimensional transmission of vulnerability through comparative studies across island regions, longitudinal data on distribution disruptions and food prices, and quantitative assessments of the relationships among connectivity, local production, household income, and dietary diversity. Such research could evaluate the explanatory power of this concept and strengthen the empirical foundation for small-island food security policies that can adapt to disruptions.

REFERENCES

Alonso, E. B., Cockx, L., & Swinnen, J. (2018). Culture and food security. *Global Food Security*, *17*, 113–127. https://doi.org/10.1016/j.gfs.2018.02.002

Atzori, D., Sonneveld, B. G. J. S., Alfarra, A., & Merbis, M. D. (2024). Nutrition fragility in isolation: Food insecurity in Small Island Developing States. *Food Security*, *16*(2), 437–453. https://doi.org/10.1007/s12571-024-01438-z

Badan Informasi Geospasial. (2025). Data batas wilayah administrasi Indonesia. *Badan Informasi Geospasial*. https://geoservices.big.go.id/rbi/rest/services/BATASWILAYAH/BATAS_WILAYAH/MapServer

Badan Pusat Statistik Kabupaten Kepulauan Seribu. (2025). Statistik kesejahteraan rakyat Kabupaten Kepulauan Seribu 2025. *Badan Pusat Statistik Kabupaten Kepulauan Seribu*. https://kepulauanseribukab.bps.go.id/id/publication/2025/11/28/b58ce4cf409b28add6a7b9b0/statistik-kesejahteraan-rakyat-kabupaten-kepulauan-seribu-2025.html

Badan Pusat Statistik Kabupaten Kepulauan Seribu. (2026). Kabupaten Kepulauan Seribu dalam angka 2026. *Badan Pusat Statistik Kabupaten Kepulauan Seribu*. https://kepulauanseribukab.bps.go.id/id/publication/2026/02/27/85a160bbcfb8886e32304453/kabupaten-kepulauan-seribu-dalam-angka-2026.html

Béné, C. (2020). Resilience of local food systems and links to food security – A review of some important concepts in the context of COVID-19 and other shocks. *Food Security*, *12*(4), 805–822. https://doi.org/10.1007/s12571-020-01076-1

Bhagtani, D., Augustus, E., Haynes, E., Iese, V., Brown, C. R., Fesaitu, J., Hambleton, I., Badrie, N., Kroll, F., Saint-Ville, A., Samuels, T. A., Forouhi, N. G., Benjamin-Neelon, S. E., & Unwin, N. (2022). Dietary Patterns, Food Insecurity, and Their Relationships with Food Sources and Social Determinants in Two Small Island Developing States. *Nutrients*, *14*(14), 2891. https://doi.org/10.3390/nu14142891

Ferguson, C. E., Tuxson, T., Mangubhai, S., Jupiter, S., Govan, H., Bonito, V., Alefaio, S., Anjiga, M., Booth, J., Boslogo, T., Boso, D., Brenier, A., Caginitoba, A., Ciriyawa, A., Fahai'ono, J. B., Fox, M., George, A., Eriksson, H., Hughes, A., … Waide, M. (2022). Local practices and production confer resilience to rural Pacific food systems during the COVID-19 pandemic. *Marine Policy*, *137*, 104954. https://doi.org/10.1016/j.marpol.2022.104954

Food and Agriculture Organization of the United Nations. (2006). Food security (Policy Brief No. 2). *Food and Agriculture Organization of the United Nations*. https://www.fao.org/fileadmin/templates/faoitaly/documents/pdf/pdf_Food_Security_Cocept_Note.pdf

Food and Agriculture Organization of the United Nations. (2025). FAO statement at the HLPF 2025 session on Small Island Developing States: Strategies for SDG success. *Food and Agriculture*

Organization of the United Nations. https://www.fao.org/new-york/fao-statements/detail/fao-statement-at-the-hlpf-2025-session-on-small-island-developing-states--strategies-for-sdg-success/en

Guell, C., Brown, C. R., Iese, V., Navunicagi, O., Wairiu, M., & Unwin, N. (2021). "We used to get food from the garden." Understanding changing practices of local food production and consumption in small island states. *Social Science & Medicine*, *284*, 114214. https://doi.org/10.1016/j.socscimed.2021.114214

Guell, C., Brown, C. R., Navunicagi, O. W., Iese, V., Badrie, N., Wairiu, M., Saint Ville, A., Unwin, N., Kiran, S., Samuels, T. A., Hambleton, I., Tukuitonga, C., Donato-Hunt, C., Kroll, F., Nugent, R., Forouhi, N. G., & Benjamin-Neelon, S. (2022). Perspectives on strengthening local food systems in Small Island Developing States. *Food Security*, *14*(5), 1227–1240. https://doi.org/10.1007/s12571-022-01281-0

Guell, C., Saint Ville, A., Anderson, S. G., Murphy, M. M., Iese, V., Kiran, S., Hickey, G. M., & Unwin, N. (2024). Small Island Developing States: addressing the intersecting challenges of non-communicable diseases, food insecurity, and climate change. *The Lancet Diabetes & Endocrinology*, *12*(6), 422–432. https://doi.org/10.1016/S2213-8587(24)00100-1

Hassan, M. A., McMichael, C., & Kothari, U. (2026). Islandness and resilience: a study of food systems in the Maldives. *Geoforum*, *169*, 104534. https://doi.org/10.1016/j.geoforum.2026.104534

Haynes, E., Bhagtani, D., Iese, V., Brown, C., Fesaitu, J., Hambleton, I., Badrie, N., Kroll, F., Guell, C., Brugulat-Panes, A., Saint Ville, A., Benjamin-Neelon, S., Foley, L., Samuels, T., Wairiu, M., Forouhi, N., Unwin, N., & on behalf of the Community Food and Health (CFaH) Team. (2020). Food Sources and Dietary Quality in Small Island Developing States: Development of Methods and Policy Relevant Novel Survey Data from the Pacific and Caribbean. *Nutrients*, *12*(11), 3350. https://doi.org/10.3390/nu12113350

Kabupaten Administrasi Kepulauan Seribu. (2023). PHE OSES tingkatkan kemandirian pakan pembudidaya ikan di Pulau Panggang. *Kabupaten Administrasi Kepulauan Seribu*. https://pulauseribu.jakarta.go.id/post/2023-07-25/phe-oses-tingkatkan-kemandirian-pakan-pembudidaya-ikan-di-pulau-panggang

Kabupaten Administrasi Kepulauan Seribu. (2024). KWT Hijau Lestari Pulau Pramuka panen 15 kilogram sayuran. *Kabupaten Administrasi Kepulauan Seribu*. https://pulauseribu.jakarta.go.id/post/2024-06-19/kwt-hijau-lestari-pulau-pramuka-panen-15-kilogram-sayuran

Kabupaten Administrasi Kepulauan Seribu. (2026). Rencana strategis Kabupaten Administrasi Kepulauan Seribu tahun 2025–2029. *Pemerintah Provinsi Daerah Khusus Ibukota Jakarta*. https://bappeda.jakarta.go.id/rpjmd/storage/documents/files/DIFLF8sBZHuNHsTiI91zXIL5iQZMrQdoqhTn99iq.pdf

Kementerian Kesehatan Republik Indonesia. (2025). Survei status gizi Indonesia (SSGI) 2024. *Kementerian Kesehatan Republik Indonesia*. https://kemkes.go.id/id/ssgi-2024-prevalensi-stunting-nasional-turun-menjadi-198

Kulke, E. (2023). Fresh food systems in small island economies of the South Pacific. *DIE ERDE – Journal of the Geographical Society of Berlin*, *154*(1), 20–26. https://doi.org/10.12854/erde-2023-652

Leunufna, S., & Evans, M. (2014). Ensuring food security in the small islands of Maluku: A community genebank approach. *Journal of Marine and Island Cultures*, *3*(2), 125–133. https://doi.org/10.1016/j.imic.2014.11.001

Prosekov, A. Y., & Ivanova, S. A. (2018). Food security: The challenge of the present. *Geoforum*, *91*, 73–77. https://doi.org/10.1016/j.geoforum.2018.02.030

Sheng, S., Zhang, P., Huang, J., & Ning, L. (2025). Research Advances and Emerging Trends in the Impact of Urban Expansion on Food Security: A Global Overview. *Agriculture*, *15*(14), 1509. https://doi.org/10.3390/agriculture15141509

Tendall, D. M., Joerin, J., Kopainsky, B., Edwards, P., Shreck, A., Le, Q. B., Kruetli, P., Grant, M., & Six, J. (2015). Food system resilience: Defining the concept. *Global Food Security*, *6*, 17–23. https://doi.org/10.1016/j.gfs.2015.08.001

Teng, P. (2020). Assuring food security in Singapore, a small island state facing COVID-19. *Food Security*, *12*(4), 801–804. https://doi.org/10.1007/s12571-020-01077-0

Yin, R. K. (2018). *Case study research and applications: Design and methods (6th ed.)*. SAGE Publications.