



Vulnerability to Food Insecurity in a Telecoupled World: Insights From Vanuatu

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Food insecurity is a pressing problem in many regions across the world. Drivers of food insecurity are becoming increasingly embedded in sociocultural and economic processes that transcend multiple spatial and temporal scales. This is due to the increasingly globalized interconnections of places and people. Understanding this complexity is essential to devise locally relevant and effective adaptation strategies to tackle existing vulnerabilities causing food insecurity. This article analytically addresses the complexity in cross-scale dynamics by combining a case study from northern Vanuatu with a conceptual analysis of the broader socioeconomic dynamics within the telecoupling framework. Our aim is to identify drivers of vulnerability that span multiple temporal and spatial scales and contribute to food insecurity in a given location while exploring the relevance and applicability of the framework for the holistic assessment of vulnerability to food insecurity. The transdisciplinary approach used in this work involved local community members and local agriculture extension officers at all stages of the study process. For this, we used complementary research methods, such as workshops, participant observations, and in-depth interviews. The results showed that potential vulnerability to food insecurity in northern Vanuatu is likely to be related to individual choices aimed at maximizing income, enabled by economic development and driven by socio-cultural changes. These choices and their consequences are perceived in many cases to be responsible for lower subsistence food production and the overuse of natural food resources. However, economic changes in particular can also enable additional livelihoods that complement existing (subsistence-based) strategies, leading to a reduction in one-sided dependencies and thus to an overall increase in the resilience of local livelihoods. We find the telecoupling approach to be a useful tool to holistically capture a local vulnerability context. However, we also encountered challenges in describing telecouplings that operate over longer time scales.

Keywords: food insecurity, livelihood vulnerability, telecoupling, Vanuatu, climate change, drivers of vulnerability, subsistence-based livelihoods

INTRODUCTION

Global environmental and societal change is often accompanied by disruptions and stressors. For instance, significant drought results in reduced crop productivity or even land use change and the degradation of soils, thus potentially increasing vulnerability to food insecurity by affecting access to and the availability of natural resources (Adger, 2006; Barnett, 2011; Connell, 2015; Lebot and Siméoni, 2015; Lowitt et al., 2015; FAO, 2016). To develop practical measures and strategies to reduce livelihood vulnerability, it is essential to understand the causal factors in all their complexity (Ribot, 2010, 2014; IPCC, 2014; Medina Hidalgo et al., 2020).

A holistic assessment of vulnerability is challenging because social and biophysical vulnerability factors coexist and are often intertwined across multiple temporal and spatial scales, making it difficult to clearly attribute impacts to root causes (Adger, 2006; IPCC, 2014; Walsh-Dilley, 2020). Globalization and the resulting increasing interconnectedness between places and people through flows of goods, information, capital, or technology have furthered this complexity and underscored the need to develop a holistic framework for understanding the causes of food insecurity (Friis and Nielsen, 2017).

Vanuatu, a small island nation in the Southwest Pacific, exemplifies the importance of such holistic vulnerability assessments. The country's limited land mass, insularity, exposure and vulnerability to natural disasters, and the deep integration of the country's economy into global markets make local livelihoods highly vulnerable to global changes (Connell, 2015; Lowitt et al., 2015). Given the essential role of subsistence farming in Vanuatu's rural livelihoods, the country is characterized by a profound interdependency between social and ecological subsystems. If perturbation or stressors of any kind affect one subsystem, other subsystems are also affected. For instance, changing food preferences following sociocultural change can affect subsistence food production or the use of natural resources and thus also the surrounding ecosystem (Allen, 2020; Savage et al., 2020).

Current vulnerability analyses can be divided into two main types, each focusing on a different spatial-temporal scale. The first type are (bottom-up) local-scale case studies that describe a specific vulnerability context primarily based on local perceptions and knowledge. These assessments are often combined with an analysis of the possible role of climate change and/or endogenous socioeconomic processes as underlying drivers of change. When links are made between local vulnerabilities and exogenous processes, they are usually general and vague [e.g., for Pacific Island Nations, see Birk, 2014; Campbell, 2015; Lebot and Siméoni, 2015]. Accordingly, such studies often have a place-based analytical perspective that tends to overlook important factors for local choices that originate in distant places (Dou et al., 2019). The second type of study uses conceptual frameworks to explain how broader exogenous processes, particularly economic change, may act as causes of vulnerability (top-down). These studies often navigate at the regional or national level but only rarely show how the described processes specifically shape vulnerabilities at the local level (e.g., Leichenko and O'Brien,

2002; O'Brien et al., 2004; Parks and Roberts, 2006; Kuchta et al., 2015).

There is a need for studies that empirically analyze how broader sociocultural and economic dynamics, including associated flows (e.g., capital and information), translate into concrete place-specific vulnerabilities (Müller et al., 2020). This requires combining the two types of vulnerability analyses: case studies at the local level and analyses along a conceptual framework. Such studies need to recognize that drivers of vulnerability can be nested and teleconnected (Adger et al., 2009), i.e., interrelated over great distances. This highlights interdependencies inherent in the system at various spatial and temporal scales and how globalization can make such interdependencies critical determinants of local vulnerability (Adger et al., 2009). Furthermore, such analyses help to develop a holistic understanding of the causal factors affecting livelihood vulnerability in a specific location, thus allowing the devising of locally relevant adaptation strategies.

We contribute to this research topic by examining a specific vulnerability context and combining a case study with a conceptual analysis of the broader socioeconomic dynamics within the telecoupling framework. First presented by Liu et al. (2013), telecoupling offers a framework to analytically address the complexities of cross-scale vulnerability factors by allowing the exploration of not only site-specific factors of change but also the contextualization of factors within broader sociocultural and economic processes and associated flows that link specific sites to distal places (Friis and Nielsen, 2017; Müller et al., 2020).

More specifically, we address two objectives. First, we explore the relevance and applicability of the telecoupling framework for a holistic vulnerability assessment. While the telecoupling framework has gained increasing attention for assessing cross-scale dynamics in land use change science (Friis and Nielsen, 2014; Hull and Liu, 2018), the framework has not yet been broadly tested by vulnerability scholars. The exceptions are Adger et al. (2009) and Eakin et al. (2009), who discussed and used the earlier framework of teleconnection to explore causes of vulnerability. The two frameworks share the idea of nested and teleconnected relationships, but only telecoupling incorporates feedback between connected systems (Friis and Nielsen, 2014). However, even within land use change science, few studies have empirically analyzed how telecouplings actually translate into changes on the ground (Friis and Nielsen, 2017).

Second, we wanted to illustrate how broader sociocultural and economic processes can lead to changes in local socioecological systems critical for sustainable local livelihoods, e.g., through impacts on outcomes or the productivity of livelihood strategies. Our aim is to provide not only an overview of the various factors responsible for vulnerability to food insecurity, but also a more detailed discussion of how local vulnerabilities are connected to broader dynamics that often transcend multiple spatial and temporal scales. In so doing, we also address some complex issues, such as colonization and Christianization, which have contributed significantly to the sociocultural and economic conditions we see today. To our knowledge, such studies are currently lacking.

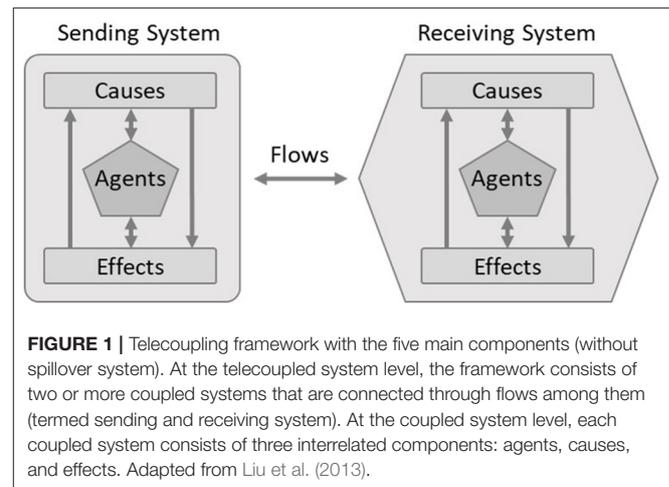
By using northern Vanuatu as a case study, our goal is to illuminate the dynamics of the vulnerability problem across multiple temporal and spatial scales while building an understanding of the vulnerabilities of a particular place, especially in relation to food insecurity. The hypotheses underlying this objective are twofold: (1) lower levels of agricultural production and reduced availability of natural resources—both potential causes of vulnerability to food insecurity in Vanuatu—are mainly the result of individual and independent choices made by local actors; and (2) these choices, in turn, are spurred by dynamics that are rooted in a nexus of wider sociocultural and economic change.

Our hypotheses build on case studies in the West Pacific region that have examined local livelihood vulnerabilities. These studies concluded that changing weather conditions act as stressors and may have a negative impact on ecosystem services and agricultural production (Mertz et al., 2010; Jackson et al., 2017; Nef et al., 2021). However, they also suggested that challenges related to agricultural production and reduced ecosystem services are primarily related to changes in management and exploitation practices (Johannes and Hickey, 2004; van der Velde et al., 2007; Lebot and Siméoni, 2015; Nef et al., 2021). The drivers of change in management and exploitation practices, and particularly how they relate to broader socioeconomic dynamics, were not clarified in these studies.

The theoretical perspectives that frame our study, including the telecoupling framework, are presented before we describe the methods. In the main body of the article, we present the results of our study in two parts. We start by introducing the case and identifying and describing particular changes considered decisive for sustainable local livelihoods, e.g., changes related to agricultural production, and can thus be regarded as factors that either promote or decrease vulnerability. Additionally, we explore various causal relationships behind these changes largely based on locals' perceptions. In the second part, we identify and outline how dynamics originating outside of the local context may have led to the observed changes at the local scale (identification of telecouplings). Part of this analysis is to describe the agents' role in facilitating or hindering flows of goods, information, capital, or technology.

ANALYTICAL FRAMEWORK

Traditionally, vulnerability has been assessed mostly by reference to either theories of hazard or theories of vulnerability as a result of entitlement failure (Adger, 2006). According to the hazard approach, the extent to which societies are vulnerable primarily depends on whether they reside in affected areas exposed to natural hazards (Adger, 2006). In contrast, the entitlement approach introduced by Sen (1982) links vulnerability, specifically to food insecurity, to people's ability to obtain enough food with existing means, including the use of production or trade opportunities. According to Sen (1982), famines and other crises occur when entitlements fail. While the emphasis on entitlements helps to highlight social differentiation in the causes and outcomes of vulnerability, the theory



puts less emphasis on the influences of biophysical dynamics (Adger, 2006). Accordingly, the entitlement approach considers vulnerability the result of processes in which people are actively involved (Adger, 2006), whereas the hazard approach tends to mark affected people as passive victims (Cannon et al., 2003).

More recent approaches, such as Turner et al.'s (2003) framework for vulnerability analysis, have attempted to integrate the concepts of natural hazards and entitlements through a system-oriented approach. Adger (2006) and Walsh-Dilley (2020) also argued that a vulnerability context should inherently be assessed from a holistic perspective, as stressors in the socioecological realm coexist and together create and perpetuate vulnerability.

A framework to analytically address the complexity of cross-scale dynamics is telecoupling (Liu et al., 2013; Müller et al., 2020) used multiple coupled systems and the connections between them as its main structure. The framework has five main components of analysis: systems, flows, actors, causes, and effects (Liu et al., 2013) (Figure 1). A telecoupling occurs when causes, e.g., sociocultural, economic, or environmental factors, generate unidirectional or bidirectional flows, e.g., capital, cultural influence, or information, between two or more coupled socioecological systems that cause a change (effects) in one or more of the systems, e.g., deforestation or loss of traditional livelihoods.

The coupled system where the flow originates is called the “sending system,” and the system that receives the flow is called the “receiving system.” Also possible are “spillover systems” that influence and/or are influenced by the interactions between the emitting and receiving systems. Within each socioecological system, agents, e.g., individuals, households, or organizations, decisively shape the resulting causes and/or effects by either promoting or impeding the flows. Interactions between different components may trigger feedback mechanisms between or within systems.

Based on the telecoupling framework, we distinguish between two different causes: the proximate and underlying. Following Geist and Lambin (2002), proximate causes are human activities or direct actions at the local level (within the receiving

system), and underlying causes (originally termed by Geist and Lambin as underlying driving forces) are large-scale, distant sociocultural and economic processes operating at longer temporal scales (originating in the sending system). Analyzing the underlying causes includes the identification and description of the sending system and the identification of possible spillover systems. Further, following Geist and Lambin (2002), we distinguish between three types of underlying factors: single causes (i.e., a single underlying cause driving one or more proximate causes), chain-logic causation (i.e., multiple interrelated underlying causes that combine to a proximate cause or directly to an effect), and simultaneous occurrence (i.e., independent, separate underlying causes driving one or more proximate causes).

METHODS

We chose a multi-method approach, with methods that transcend the boundaries between science and society (Pohl et al., 2017), and collected both primary and secondary data.

Primary data consisted of local knowledge from local residents and key informants. We used local knowledge for three reasons. First, local knowledge highlighted local perspectives and perceptions. We collaborated with local agriculture extension officers and members of local communities to form a common research goal and to develop the tentative research design for this study (Jahn et al., 2012). This participatory problem definition ensured the relevance of the findings to the local population. Second, local knowledge provided the granularity needed to capture site-specific factors of vulnerability. Third, local perspectives and perceptions allowed us to evaluate the new knowledge for its contribution to the social and scientific process, thus enabling social learning and empowerment among local actors (Fazey et al., 2010; Jahn et al., 2012), and to triangulate and increase the robustness of the results (Creswell and Miller, 2000). Local knowledge was collected through classical social research methods to be explained in the next section.

We used secondary data to contrast our empirical data with scientific findings from similar contexts. Furthermore, secondary data enabled us to explore telecouplings by allowing us to capture and describe exogenous dynamics beyond the

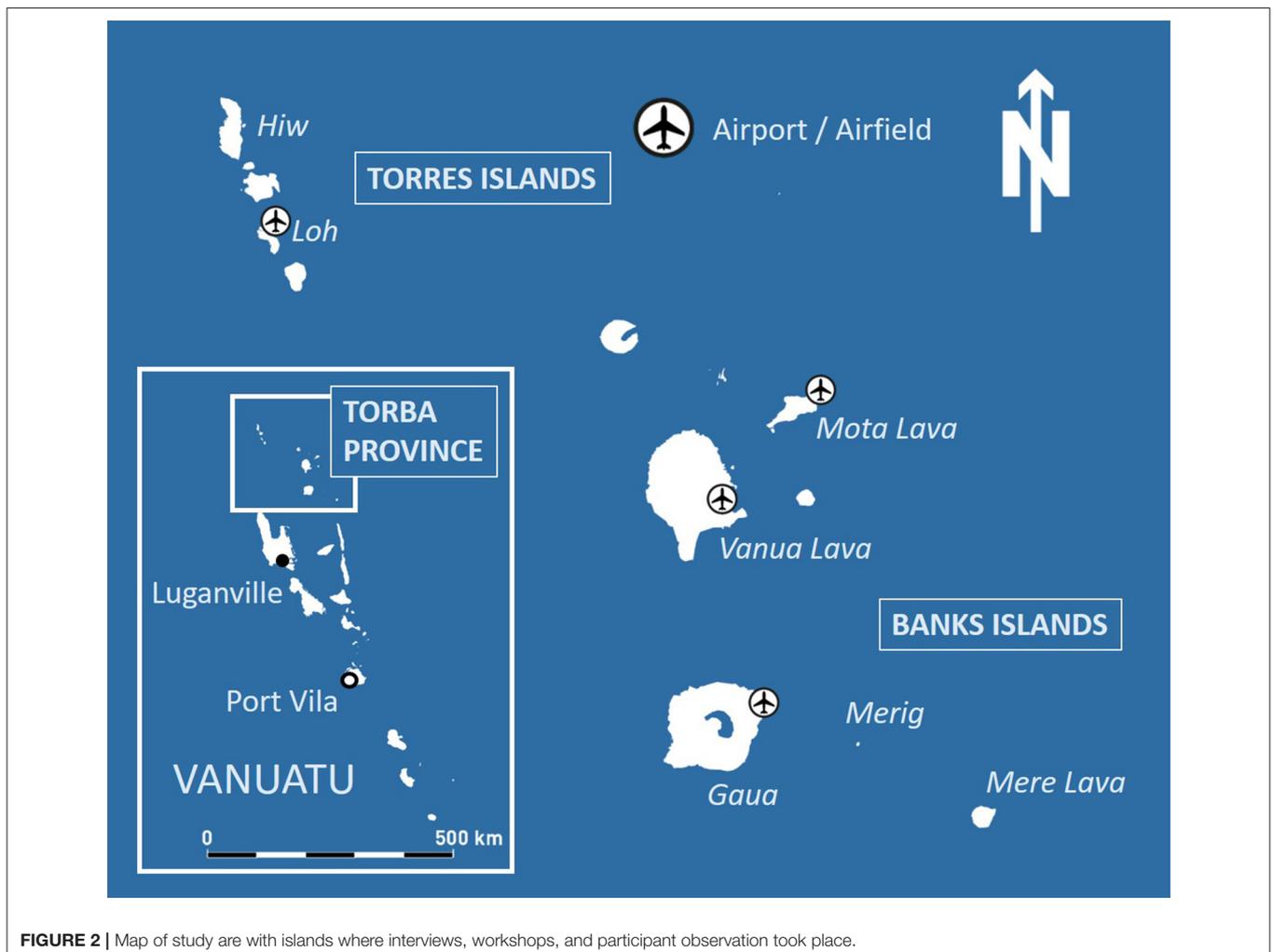


FIGURE 2 | Map of study area with islands where interviews, workshops, and participant observation took place.

control of the respective communities and to contextualize local processes within these dynamics. First, we reviewed academic peer-reviewed literature. We used the search terms “vulnerability to food insecurity,” “telecouplings,” “sociocultural transformation OR change,” “economic transformation OR change,” and “history Vanuatu” in the Web of Science database. We refined and/or narrowed down our search further based on the results. Second, we extended our search to institutional literature and data from Vanuatu’s Statistics Office. Third, to find relevant publications and data, we used the same search terms and searched Google Scholar and the websites of international organizations active in vulnerability assessments, preferably in the Pacific region.

Study Design

We collected primary data from twelve communities on seven islands, all belonging to Torba, the northernmost province of Vanuatu (**Figure 2**). The food production system of these communities formed our “receiving system.”

Torba consists of two groups of islands, the Banks Islands and the Torres Islands, where about 9,500 people live on a land area of 882 km² (Vanuatu National Statistics Office [VNSO], 2009). Vanuatu faces what Reenberg et al. (2008) described as the “classic” challenge of rapidly growing populations in the context of limited farmland and natural resources and also “modern” challenges (Nunn et al., 2014) related to the region’s increasing exposure to the global economy. Not all islands are equally affected by these challenges. For example, the different islands in Torba are affected by different demographic trends. While Gaua or Vanua Lava experienced strong population growth of about 35 and 19%, respectively, from 2009 to 2020, the more remote islands in the Banks group, such as Mere Lava or Merig, experienced no growth or even a slight decline in population over the same period (**Supplementary Material 1**). However, data from previous censuses show that rapid population growth can also occur on remote islands. For example, between 1999 and 2009, the population of Loh grew by 51% and the population of Hiw by 35% (Vanuatu National Statistics Office [VNSO], 2012). Yet, an island’s degree of isolation is likely to be an important factor in determining the extent of the impact of socio-cultural dynamics, particularly in relation to “modern” economic challenges. Both types of islands can be found in the province of Torba. Those that are largely isolated from the rest of the country due to their location or lack of infrastructure, and those that have connections to the country’s centers and thus access to national or even international markets. This gradient of isolation allows us to compare islands to elucidate the influences of these processes on local livelihoods.

Therefore, the communities were selected primarily based on their relative isolation and degree of exposure to wider socioeconomic dynamics. We used the criteria of mobile phone coverage (and thus internet access), flight connections per week and number of supply ships per month to determine whether an island is “isolated” from or connected to the rest of the country, as these connections enable the flow of goods, people and information (**Supplementary Material 1**). However, depending on the question, the different criteria have different relevance for whether or not an island is considered “isolated”. For the

cultivation of crops, for example, regular ship connections are important in order to be able to bring the goods to the buyers. For tourism, on the other hand, it is important to have reliable communication channels (mobile phone coverage) and regular air connections.

Data Collection

This article builds on ethnographic work in north Vanuatu using data collected from 2015 to 2020. Collection of primary data was conducted in three phases: an explorative phase and two core phases (**Table 1**). The explorative phase, which lasted from March to August 2015, provided the framework for this study and contextual understanding. The two main phases of data collection took place between (1) August and November 2016 and (2) May and June 2019.

We present data from 54 face-to-face semi-structured interviews with local villagers. Additionally, the data includes findings from four workshops conducted in the field with villager participants. The interviews and workshops are supplemented by numerous informal-conversations and 6 months of participant observation in the field (**Table 1**).

For the face-to-face interviews with residents, we selected 3–20 residents per island. To secure diversity, we considered gender and age, with the youngest respondent being 18 and the oldest 92. For the workshops and focus group discussions, we recruited participants using the snowball method (Goodman, 1961) from among the acquaintances of the residents who had already been interviewed. We conducted two focus group discussions and four workshops. At the beginning of each workshop, we used gender-specific resource mapping to understand how residents access and control resources. Furthermore, all methods, with community residents as the target group, focused on residents’ economic activities and situation, agricultural practices, and local sociocultural and economic changes and their impact on livelihood strategies (proximate causes and the role of actors in the receiving system).

While each interview lasted between 45 and 90 min, the workshops and focus group discussions lasted between 2 and 4 h. All interactions happened either in English, Bislama (the lingua franca of Vanuatu), or in one of the four island-specific vernacular languages. In the last case, local research partners simultaneously translated responses into English or Bislama.

Data Analysis

For the interviews, focus group discussions, and workshops, we produced a summarizing protocol by paraphrasing information during transcriptions. In this process, we condensed information by excluding less relevant or redundant information and by grouping similar statements into higher-level statements (Mayring, 2002, p. 94–98). To ensure the systematic documentation of findings from participant observations, we followed the structure suggested by Bernard (2006) and categorized our field notes into descriptive, analytical, and methodological notes.

The qualitative analysis of the primary data drew on the approach presented by Ritchie et al. (2003) and consisted of three main steps: (1) data management (building a thematic

TABLE 1 | Overview of applied methods.

Method	Target group	Phase (period of collection)	Sample size	Age group			Gender		Location (no. of islands and no. of interviews)	
				18-30	31-40	40+	F	M	Isolated	Connected
Participant observation	Residents	Explorative Main (1)	Residents of 2 communities						1	1
Focus group	Residents	Main (1)	2 sessions; <i>N</i> = 17	7	3	7	7	10	1	
Workshops	Residents	Main (2)	4 session; <i>N</i> = 65				31	34	1	3
S-S-Interviews (face-to-face)	Residents	Main (1)	<i>N</i> = 19	6	6	7	6	13	1 (<i>n</i> = 16)	2 (<i>n</i> = 3)
		Main (2)	<i>N</i> = 44				22	22	4 (<i>n</i> = 11)	7 (<i>n</i> = 33)

framework), (2) descriptive accounts, and (3) explanatory accounts (p. 220–248). The first step was guided by a series of questions adapted from Böhm (2012) to familiarize us with the field and data, identify initial themes or concepts, and create an index. This index served as a basis for building an initial thematic framework, which we then used to code (index) the data and conduct the iterative process of descriptive analysis. The goal of this analysis was to define categories and classify the data, as well as refine the thematic framework where necessary. Based on these findings, we conducted an associative analysis (explanatory accounts) to identify relationships between the identified phenomena. The associative analysis provided the necessary insights to describe dynamics (effect, causes, and actors) within a subsystem (receiving, sending) or between them (telecouplings).

CHARACTERISTICS OF AND PROXIMATE CAUSES FOR VULNERABILITY IN NORTHERN VANUATU

This section examines vulnerability to food insecurity and its proximate causes, focusing on local perceptions. In each identified case, this perception is contrasted to findings from other parts of the country or adjacent regions. We begin by elaborating on subsistence gardening as the main form of livelihood in northern Vanuatu, and we focus on potential vulnerabilities associated with these strategies and underlying proximate causes. We continue with other food sources, such as the sea and forests, before examining social changes at the local level that could be drivers of proximate causes or that themselves act as proximate causes.

Subsistence Gardening

Gardening contributes to subsistence to a large extent while providing a high level of food security (Walter and Lebot, 2007; Allen, 2015). Traditional subsistence gardening is based on the annual clearing of an area of forest for a multi-crop family garden. These gardens are rain-fed, and according to traditional practices, cultivated for one or more years before being left fallow for five to seven years (Weightman, 1989). Gardens are often complemented by family-based cultivation

of permanent cash crops, such as coconuts or kava. The most popular crops cultivated in these agroforestry perennial gardens are manioc, banana, island cabbage, yam, sweet potato, papaya, taro fiji, and island taro (Vanuatu National Statistics Office [VNSO], 2016) (see **Supplementary Material 2** for details on species and taxonomy).

The local population perceived the productivity of the gardens to have decreased in some cases. These declines in production have been at least partially compensated for by other food sources, such as imported food. Lower productivity is mainly attributed by local populations to climate change and to changing gardening practices that increasingly no longer conform to traditional practices (Savage et al., 2020; Nef et al., 2021). For example, in several cases, shifting cultivation has been abandoned or has been significantly modified by extending the duration of the cultivation of a field and/or shortening the fallow period, especially on islands or around communities with a high population density (Lebot and Siméoni, 2015; Nef et al., 2021). Some farmers see a link between these changes in shifting cultivation and the productivity of gardens. A participant from Mota Lava explained: “Because we stopped using the traditional rotation technique, the productivity of gardens is going down” (Interview, farmer, Mota Lava). However, none of the study participants could elaborate on this causal relationship. There are also no clear findings on this in the literature. Lebot and Siméoni (2015), for example, observed on other islands of Vanuatu and in soils similar to those in our study site (Quantin, 1982) that longer cropping periods can indeed lead to a loss of soil fertility, but that this depletion is not necessarily associated with lower yields. Mertz et al. (2008) also concluded in their study in Southeast Asia that fallow length correlates only weakly with crop yield.

Another factor considered by study participants to be a potential cause of productivity decline is the increased incidence of pests and diseases. While some farmers link this development to changing climatic conditions, i.e., drier and warmer climates, some see a connection with crops being increasingly planted in a combination and sequence that does not correspond to traditional crop schemes. While these causal links have been documented in similar systems (Vogliano et al., 2021), Lebot and Siméoni (2015) and local experts also attribute the increased pressure of pests and diseases to the genetic impoverishment of some, especially more recently introduced plants, i.e., sweet

potato or cassava. Most likely, a combination of causes has led to vulnerability to diseases, pathogens, and related crop losses.

More evident is the impact on food security when farmers expand the area for the cultivation of cash crops. The cultivation of copra in Mota Lava and kava in Gaua Lava illustrates this conflict well. While an increasing expansion of cash crop production on the sparsely populated island of Gaua mainly takes place at the expense of forest ecosystems, it has led to a shortage of land for subsistence food production on the more populated island of Mota Lava, which has fewer forests. As a result, shifting cultivation is being further restricted, for example, by shortening the fallow period. But even on islands that are not yet affected by land scarcity due to their low population density, this could change because of rapid population growth, such as on Gaua, where the population increased by over 30 % between 2009 and 2020 (**Supplementary Material 1**). Similar intensification of land use for subsistence agriculture has also been observed on other islands in Vanuatu (Allen, 2001; Savage et al., 2020). Such a development potentially promotes the shift toward alternative, mostly imported, food sources. This may give rise to further dependencies, e.g., on the supply of these foods and that they remain affordable, and on volatile market prices for cash crops (Campbell, 2015; Lebot and Siméoni, 2015).

Furthermore, local farmers consider a lack of adherence to (traditional) planting calendars and thus the incorrect timing of planting and harvesting to be a possible cause of lower productivity (Nef et al., 2021). Incorrect planting timing may result in specific growth stages taking place under weather conditions that do not suit the plants' needs, thus reducing the plants' vigor and/or resulting in partial crop failure. Similar observations in the neighboring Solomon Islands have shown that the link between changing cropping practices and increased vulnerability to food insecurity is not a phenomenon restricted to north Vanuatu. Birk (2014) concluded that changes in the timing of planting and harvesting, tending, fallow, rotation, and forms of intercropping also contribute significantly to food insecurity in the Solomon Islands' Temotu Province, which borders Vanuatu.

Sea, Forest, and Other Food Sources

Besides food produced in gardens, seafood, “store-purchased” food, and forest products are important constituents of the daily local diet. This pattern is typical for all of Vanuatu (Vanuatu National Statistics Office [VNSO], 2009; Feeny et al., 2013; Allen, 2015; Lebot and Siméoni, 2015). There are, however, some differences between islands. Imported basic staples such as rice, flour, tinned meat, or fish have become a firm source of calories, partially replacing traditional diets on some islands, e.g., on Mota Lava or Gaua, while store-purchased food is negligible on other islands such as Hiw, Mere Lava, and Merig (Nef et al., 2021). Particularly elderly people are partly dependent on imported food, as they are no longer able to cultivate their gardens themselves. This is especially the case when younger family members have migrated to other islands and are therefore no longer able to support their relatives in gardening. In such cases, remittances from these family members are often the main source of income. Two elderly people from our sample stated that they depend almost exclusively on these remittances and use

them mainly to buy local and imported food. The increasing role of imported food, and thus reliance on external sources, is a trend that is not unique to North Vanuatu but evident throughout the country and the region (Allen, 2015; Lebot and Siméoni, 2015; Charlton et al., 2016).

Furthermore, marine and terrestrial ecosystems are important sources of staples, specifically protein on the subsistence level (Amos, 2007). More than half of all residents in north Vanuatu consider seafood, especially various shallow-water reef fish and mollusks, to be the second most important food source after subsistence farming (Nef et al., 2021). In contrast, forests are much less important as a food source, with some differences between islands. For example, resources such as land crabs, coconut crabs, or eggs from the Vanuatu scrub fowl are an integral part of the local diet on Hiw, while these resources are of negligible importance on Mota Lava. On some islands, especially remote islands with small populations, such as Hiw or Merig, ecosystem services also serve as a safety net for communities when crops fail, e.g., during disasters such as hurricanes. This is possible because the ecosystems are still largely intact and the relevant species, such as land crabs or wild yam, are still present in sufficient abundance. Together with the cultivated yam, wild yam is among the traditional Pacific Island food crops most resilient to high winds (Campbell and Chung, 1986). Torres Islanders have also reported on several other forest products that are exploited in cases of food shortage, such as nuts from different trees and leafy greens.

In northern Vanuatu, nearshore marine and terrestrial resources are managed by customary practices that are based on land tenure, traditional ecological knowledge, and organizational structures. These practices allow communities or landowners to promote the recovery of a species through temporary prohibitions (*kastom* taboos). On all the surveyed islands, except Merig, more than half of the residents (62%) reported that the use of marine resources is restricted to at least one place where interviewees collect resources. In contrast, *kastom* taboos to protect terrestrial flora or fauna are less common and only affect respondents' collecting activities on Gaua, Hiw, and Loh.

Management by traditional villagers does not necessarily imply sustainable use (Johannes, 1998). Despite protection efforts, interview respondents of all islands, except Merig, observed a decrease in both terrestrial and marine resources. Among terrestrial resources, coconut crabs and wild yam are particularly affected. On some densely populated islands, for example Mota Lava, both species are rarely found. Only on remote islands, such as Hiw, do they occur in relatively large numbers. However, interviewees and focus group discussion participants noted significant declines on these islands as well, especially near settlements.

Other terrestrial resources showing declines include various woody plants, land crabs, and various bird species. A woman from Hiw reported that “where we caught six to seven coconut crabs per trap per night a few years ago and even last year, we only catch one or two crabs today. [...] especially around settlements the situation is dramatic” (Interview, translated from Bislama, Hiw). Interview participants also noted significant declines in various shallow-water reef fish, lobsters, and mollusks. As with

terrestrial resources, there is strong variation among islands, with declines primarily noted on densely populated islands.

Officially, the stock of only a few species, e.g., for the coconut crab or lobsters, is regularly recorded as part of nationwide assessment surveys carried out by the Department of Fisheries of Vanuatu. Information on the size of populations can also be derived from the domestic trade volumes of some species. Both the figures from national monitoring programs and trade volumes largely support the local perception (Amos, 2007). Stock status of other species, e.g., land crabs and reef fish, are unknown.

According to interviewees, one reason for declining natural resources is the disregard of rules or decisions despite their customary legitimization. For example, some landowners in Gaua complain that the taboos (restricting use of natural resources) they have enacted to protect areas for populations to recover are not always respected. While in Gaua disrespecting customary taboos has been observed for some time, this seems to be a new phenomenon in Hiw. According to local leaders, the taboo, which has been in place for 40 years to protect the largest nature reserve on the island, has always been strictly respected. Strict observance is attributed to fear and respect for traditional rituals performed to legitimize and reinforce the taboo. However, recently (2016), the taboo was repeatedly violated. Local villagers reported that lobsters and coconut crabs were collected on several occasions.

Changes in Local Structures as Proximate Causes

Non-adherence to rules and/or the abandonment of traditional practices were mentioned by study participants as possible drivers of change in both gardens and natural resource management. The following section discusses how these drivers are related and what social changes or phenomena they might be connected to from the perspective of the affected communities. **Table 2** provides an overview of this section and contextualizes the drivers discussed with broader sociocultural and economic processes.

Erosion of Customary Structures Weakens Community Governance and Causes Loss of Traditional Knowledge

Local daily life and community coexistence are shaped and guided by strong social cohesion and customary structures and practices, such as the complex inheritance of land and rights, locally referred to as *kastom*. This also provides the framework for local economic activities, e.g., the use of natural resources (Ruddle et al., 1992; Addinsall et al., 2016). When asked whether living together in the community has changed, older respondents in particular answered that traditional structures and processes in daily life have become less important. “We lost *kastom*” was a regularly given statement during interviews on all islands. Whereas some respondents deliberately addressed all of society, others specified that “[...] especially younger generations lost their respect toward *kastom*” (Interview, translated from Bislama, Hiw). Losing *kastom* was often associated with a loss of respect for *kastom* by the study participants. This included the general loss of respect for traditional norms and values and

specifically the loss of respect for the authority of certain groups of people, such as village chiefs or landowners. Additionally, across all islands, the majority of study participants felt that trust among villagers had generally declined. Yet, people in general still trust each other, even if it is no longer than unconditional, as it once seemed. “You just have to be more careful who you trust,” said a study participant from Gaua. According to respondents, a lack of respect and trust manifests as disregard for rules or decisions despite their customary legitimization.

The perception is that decisions are increasingly being made based on personal rather than collective interests. One elderly study participant explained this process as follows: “There are three types of decision-making in north Vanuatu: (1) unilateral decisions by individuals legitimized through *kastom* that aim to preserve and promote the well-being of the community, (2) unilateral decisions made with the intention of pursuing individual goals, and (3) Western decision-making through an open participatory (democratic) process. However, unilateral decisions favoring single goals have become the predominant motivation in decision making” (Mota Lava, participant observation [informal discussion], translated from Bislama). The motivation underlying individual decisions and the disregard of taboos may differ between islands. In the case of Gaua, taboos are violated to catch fish primarily for self-sufficiency, and only some are sold at local markets. Often, violators have no or only indirect access to the resource through kinship, as they do not own land with access to the sea. In Hiw, the main resources collected in the protected area are coconut crabs and lobsters, both of which are economically valuable, making these decisions based more on economic interests than on food security. An example from the small island of Rah shows that rules set by the chief for the good of the community are nevertheless respected in some cases. However, unlike in Gaua or Hiw, the protected area in Rah is within sight of a busy stretch of coastline. Accordingly, strong social control is responsible for extensive compliance with existing restrictions.

In addition to individual motivation, decreasing respect for the chief’s decisions and thus the erosion of his authority is seen as a consequence of his changed role. In the past, the chief was an “all-knowing” person. This is no longer the case, as many people, especially younger ones, have acquired knowledge independent of traditional structures through their schooling. This is, according to some interviewees, weakening a chiefs’ position. Individual empowerment through schooling is seen as positive by many, especially younger interviewees, but also criticized by others. As one of the interviewees from Gaua noted, schooling enables “own thinking,” which may not always be conducive to community interests. Another participant from Hiw noted that secondary school in particular changes the “mindset of young people” and that this development is ultimately responsible for the decreasing respect for tradition.

The vast majority of interviewees stated that they had learned to plant gardens from their parents, grandparents, uncles, or aunts. However, interviewees from Mota Lava and Gaua also observed an increasing erosion of traditional structures that enable and regulate such knowledge transfer within kinships or communities. As a result, not only knowledge about *kastom*

TABLE 2 | Potential underlying causes (sending system) and proximate causes (receiving system) for the effects that favor vulnerability to food insecurity in northern Vanuatu.

Cluster	Underlying cause and effects in sending system	Intermediate effects (conditions that favor change in behavior)	Proximate causes (receiving system; several interlinked causes possible)	Effects on vulnerability to food insecurity (receiving system: rural/traditional livelihood system)	Agents	Flows
Econ	Growing number of foreign tourists	Creates demand for valuable natural resources, i.e., specific species, for culinary purposes	Reallocation of labor to realize the economic potential arising from the demand for natural resources	<ul style="list-style-type: none"> - Unsustainable use of natural resources (+); - provides additional income (-); - increase dependency on global dynamics (e.g., COVID-19) (+) 	<ul style="list-style-type: none"> - Local populations; - Tourists; - Hotels/restaurants; - Traders 	<ul style="list-style-type: none"> S → R, Money, tourists; R → S, Natural resources
Econ	Increased quality requirements for copra	Weakens the competitiveness of producers in Vanuatu on world market	Villagers maximize their income by reallocating assets (e.g., labor) to profitable cash crops leading to land use change	<ul style="list-style-type: none"> - Less land for subsistence gardening leads to changes in gardening practices (shortening fallow period) (+); ■ increased dependency on imported food supply and volatility of prices (-); - increased pressure on forests (+); - increased monetary income (-); - increased dependency on volatile market prices for cash crops (+) 	<ul style="list-style-type: none"> - Local populations (plantation owners); - Buyers; - Government; - WTO members 	<ul style="list-style-type: none"> S → R, information (price and trade information), capital; R → S, products (crops/goods)
Econ	Falling market prices for copra (increasing market competition)	Deprives economic viability of copra production.				
Econ	Vanuatu commits to suspend subsidies for copra producers					
Econ	Court in Germany revises ruling on kava import ban	Creates new sales markets that increase the profitability of kava production				
Econ	Bilateral labor agreements allow Vanuatu to send temporary migrant workers to host countries	Provides otherwise rare employment opportunities	Maximization of income by reallocating labor to more profitable activities, i.e., seasonal work abroad, leading to changes in gardening practices or neglect of gardens	<ul style="list-style-type: none"> - Decrease in the productivity of gardens (+), - double burden for women (+), - increased monetary income (-), - increased dependency on imported food supply and volatility of prices (+), - increased dependency on political framework conditions (e.g., restrictions due to COVID-19) (+) 	<ul style="list-style-type: none"> - Vanuatu's Department of Labor and Employment Services; - Governments of other states; - Women; - Employers (abroad); - Seasonal workers 	<ul style="list-style-type: none"> S → R, jobs, capital; R → S, labor (people)
		Exposure to globalized society with new values and norms, including the concept of individualism, creates new needs and desires (Westernization)	Reallocation of assets (e.g., labor) to profitable activities to meet new needs	<ul style="list-style-type: none"> - Unsustainable use of natural resources (+); - decreased productivity of gardens (+) 	<ul style="list-style-type: none"> - Tourists; - media content; - tourists; - media; - Christian denominations 	<ul style="list-style-type: none"> S → R; New norms, values, and concepts (e.g., media content)
Econ	Globalized media content		Erosion of customary structures (<i>kastom</i>) weakens community governance (e.g., legitimization of decisions) and causes loss of traditional knowledge	<ul style="list-style-type: none"> - Non-adherence to rules may lead to unsustainable use of natural resources (decline in terrestrial/marine resources) (+); - decreased productivity of gardens (abandoning traditional practices, e.g., planting calendar) (+) 		
SoCul	Education or work opportunities in economic centers					
SoCul	Current and past Christianization	Introduced new beliefs that are partially incompatible with <i>kastom</i>				
SoCul	Western educational system	Explicit (or implicit) calls for commitment	Time conflicts with other activities (e.g., gardens) due to the reallocation of labor leads to changes in gardening practices or neglect of gardens	<ul style="list-style-type: none"> - Decreased productivity of gardens (+); - double burden (+); - Increase in monetary income (-); - Increased dependency on imported food supply and volatility of prices (+) 	<ul style="list-style-type: none"> - Christian denominations; - Vanuatu's Ministry of Education and Training; - Local schools; - Local populations 	<ul style="list-style-type: none"> S → R; Norms, values, and concepts (political cultural influence)
SoCul	Disaster relief programs coordinated by National Disaster Management Office (NDMO)	Makes traditional coping strategies obsolete	Loss of traditional knowledge related to traditional coping strategies	<ul style="list-style-type: none"> - Loss of traditional coping strategies (+); - increased dependency on disaster relief programs (+); - provides fast disaster relief (prevents famine) (-) 	<ul style="list-style-type: none"> - Vanuatu's NDMO; - Foreign aid agencies; - Local populations 	<ul style="list-style-type: none"> S → R; New norms, values, and concepts

For all telecouplings, the table lists the most affected/involved actors and the identified flows.

S → R describe a flow from the sending to the receiving system.

R → S describes a flow from the receiving system to the sending system.

The (+) sign indicates an increase and the (-) sign indicates a decrease in vulnerability to food insecurity.

itself has been lost, but also traditional ecological knowledge and knowledge of how to manage traditional gardens, i.e., time for planting and crop rotation. In contrast, traditional knowledge in Merig, Mere Lava, and Hiw still seems to be passed down from generation to generation. All respondents of these islands stated that they still cultivate their gardens in the traditional way they learned from their parents and grandparents.

New Needs and Wants

Often in informal conversations, but also in interviews, so-called “Western” values and norms were held responsible for the abandonment of traditional lifestyles. According to some respondents, young people in particular are increasingly orienting themselves toward these Western concepts of what is important, a process often referred to as “Westernization”. Western culture was not defined more precisely, as most study participants used the term broadly to refer to all influences from outside Melanesian culture.

In particular, the pursuit of consumption and self-determination is perceived as a Western concept. On Hiw, one resident attributes the rapidly growing trend of cell phone ownership to the fact that young people in particular are increasingly “falling for the temptations of the modern world. [...] Their [young people’s] interests are sports, music, and fancy gadgets, e.g., smartphones and tablets. All their needs are defined by these personal interests” (Interview, translated from Bislama, Hiw). Whereas music and sports indeed have been mentioned particularly by young people to be important for their well-being, the desire for “fancy gadgets” was not reflected in the statements either about the prerequisite for well-being or consumer behavior. Nonetheless, according to interviewees, buying credit to use telecommunication services has become a main staple in people’s budgets.

Most consumer goods that are desired or actually purchased serve the direct satisfaction of needs, e.g., food, clothing, or medicines. Interviewees stated that they spend more money on imported food than on locally produced food. Especially popular are rice, tinned meat and fish, sugar, flour, and biscuits. This change in preferences toward “Western food stuff” (Mota Lava, interview) is seen by some study participants as an indication of an increasingly Westernized lifestyle. While individual consumption is indeed largely governed by individual resources and behaviors that are conditioned by social norms (Müller et al., 2020), locals, especially women, also explained the change in preference with practical reasons. Specifically, the preparation of these dishes is much less time-consuming than preparing local dishes. Such reasoning has also been voiced in other parts of the country (Savage et al., 2020) and in the neighboring Solomon Island (Vogliano et al., 2021). Overall, however, imported food is seen as neutral and only occasionally as an unnecessary expenditure or even harmful to health.

The extent to which an adaptation to a Western lifestyle has taken place and thus new needs have arisen, or whether an expanded range of goods and services merely serves existing basic needs, is in the eye of the beholder. Differences in viewpoints exist most notably between generations. While older generations tended to view all changes as “Western” and doubt their meaning

and purpose, at least in part, younger study participants tended to be less critical of these changes. However, views within an age group are not uniform. Even some younger people see at least parts of this development as Westernization and harmful to *kastom*, while some older people see this development as beneficial and not indicative of Westernization.

However, there is greater consensus that this change in consumer behavior has generally resulted in an increased need for money. According to many study participants, this has not only led to an optimization of utility in livelihood strategies but also to more individualism. Consequently, former mutually shared social norms and thus rules of coexistence, for example *kastom* taboos, have been abandoned in favor of more self-centered behavior. The challenge is to reconcile traditional values with an emerging consumer society whose dynamics put significant pressure on natural resources (Veitayaki and Novaczek, 2005). One interviewee from Hiw described this shift away from communitarianism toward individualism as a result of changing consumer behavior as follows: “Money makes us leave our culture, since [...] most people spend their money on things that satisfy their immediate personal needs [...] but not for communal purposes” (Interview, farmer, Mota Lava).

TELECOUPLINGS—FROM UNDERLYING CAUSES TO PROXIMATE CAUSES

This section explores possible underlying causes that have prompted locals to change their gardening and exploitation practices or that have induced observed changes in local structures. Underlying causes can directly lead to changes in management practices by leaving locals with no other choice, for example, through trading restrictions. In most cases, however, underlying causes create conditions that encourage behavioral changes and thus changes in management practices, e.g., by creating new income opportunities. In the following, we refer to these conditions as the intermediate effects of underlying causes.

We identified economic and sociocultural factors as the main clusters of underlying causes that are likely to lead to the observed proximate causes in the receiving system. However, a neat distinction is often not possible, as there are numerous overlaps and interactions. Immediate causes may therefore be driven by a single underlying cause or several interlinked causes from multiple clusters and originating from different sending systems. Furthermore, the underlying causes may lie in the past and/or extend over longer periods of time. The description of the two clusters is therefore structured along a temporal sequence, whereby we start with the events that occurred furthest in the past. **Table 2** presents a summary of this section.

Economic Causes

New Economic Opportunities

Arguably, one of the most significant economic processes was the expansion of the cash economy to Vanuatu, resulting in access to international markets and the emergence of national markets (Ruddle, 1993). This process started at the beginning of the 20th century during the early colonial area in the economic

centers of the country and consolidated and spread to more remote islands in the decades that followed (Campbell, 2015). As part of this expansion, infrastructure in the country was developed, and remote islands were connected to the rest of the country either by sea or by air. This allowed locals to commercialize natural resources and garden products, creating opportunities to maximize benefits by reallocating labor and time to more profitable activities. While these activities became the main source of income on remote islands, a service industry dominated by expatriates emerged on islands with international air connections, especially tourism, and became the country's most important industry (Cox et al., 2007).

The number of overseas visitors, particularly from Australia and New Zealand, nearly doubled between 2004 and 2019 before the industry collapsed due to the COVID-19 pandemic in 2020 (Vanuatu National Statistics Office [VNSO], 2021). Growing tourism in turn fueled domestic demand for natural resources, especially for coconut crabs and lobsters for culinary reasons (Amos, 2007).

In northern Vanuatu, economic development has led to large-scale cultivation of coconuts for copra production and increased trade in natural resources. In the Torres Islands, for example, the opening of the airstrip on Linua in the late 70s enabled trade in coconut crab. In the following years, trade grew greatly, reaching its peak in the 80s, where approximately 100,000 crabs were exported per year (Amos, 2007). A resident of Hiw illustrated how the sale of natural resources, which has now become possible, has led to a redistribution of labor: "If you spend a whole night diving for lobsters or hunting for crabs, you can make 15,000 Vatu. If you plant 100 tobacco plants, you only make 10,000 Vatu, and it takes 3 months or so [until the product can be sold]" (Interview, farmer, translated from Bislama, Hiw). The downside of this development is a dramatic decline in the population of coconut crabs in some Torres Islands, limiting the resource's availability as an important source of protein for locals. The market has reacted to the population decline and the associated supply shortage with an increased price level. According to Hiw respondents, higher prices in turn have encouraged people to increase their collection efforts, which in some places has eventually led to a collapse in populations of both species, but especially of coconut crabs.

On the Banks islands, access to markets has considerably shaped local livelihoods. In particular, coconut cultivation for the production of copra became the main source of income. Another important reason that enabled large-scale coconut plantations was the abundance of available land. Low population density due to depopulation, which began with the introduction of disease and was further exacerbated by labor trafficking, freed up land that had previously been used for agricultural production (Campbell, 2015). This allowed copra production without compromising subsistence food production and thus jeopardizing food security. With the demographic turn in the 1950s and subsequent population growth, coconut cultivation increasingly happened at the expense of subsistence food production or forests, as observed on Gaua and Mota Lava (Campbell, 2015; Lebot and Siméoni, 2015).

Exposure to Volatile Market Prices

Besides depleting resources and increasing land scarcity, volatile market prices also pose a major challenge. Especially after significant price declines and expiring subsidy programs, Vanuatu growers have faced increasing difficulty competing with other producers, especially from the Philippines and Indonesia. These two countries are not only the two largest markets for copra produced in Vanuatu, they are themselves the world's largest producers and processors of copra. One reason for low competitiveness is the low profit margin in Vanuatu due to the long transport distances. Furthermore, quality requirements for copra have increased. While other producers have been able to adapt their production to meet the quality requirements, producers in Vanuatu can hardly meet them as the country lacks the necessary infrastructure (UNCTAD, 2016). This has further depressed the prices paid for copra produced in Vanuatu.

Vanuatu periodically used subsidies to alleviate sharp price declines, with the goal of protecting incomes that rely greatly on copra (Grynberg and Joy, 2000). However, Vanuatu was forced to discontinue these price supports as a precondition for the country's accession to the World Trade Organization (WTO). A former producer from Gaua said that for some time now it has "simply not been profitable to engage in this labor-intensive activity" (Interview, translated from Bislama, Gaua), which is why he has ceased copra production. He described a trend seen throughout the country (UNCTAD, 2016). Since 2017, copra exports have fallen by 85%.

While world market prices and quality issues brought down much of the local copra industry, revised court decisions in Europe and quality standards paved the way for a big boost in another export: kava. In 2014, a German court overturned the European import ban on kava that was imposed in 2002 due to unclear health risks (Lebot and Siméoni, 2015; Aporosa, 2019). This ban left only Australia as a potentially important market (Aporosa, 2019). To strengthen the sustainability of kava exports, producing countries in the Pacific have agreed on quality standards for kava exports that allow them to register under the FAO/WHO Codex Alimentarius. Between 2017 and 2019, exports of kava increased by more than 130%. This boom has also left its mark on the islands of Torba, especially on Gaua. Ten out of 13 respondents indicated that they had recently started growing this highly demanded and profitable crop.

Efficient Resource Allocation

New economic opportunities allowed for an increase in income as they offered new possibilities for a more efficient allocation of resources. For example, investing a certain amount of labor in the production of kava promises a higher financial return than investing that labor in the cultivation of yam. The associated redistribution of capital can potentially have a negative impact on traditional gardens (Savage et al., 2020). For example, time conflicts were repeatedly cited in both the interviews and workshops as a reason for not being able to cultivate the gardens. In other words, the capital invested in cash crop production and the exploitation of natural resources for commercial purposes are missing from gardening. The reallocation of capital may also undermine traditional subsistence fishing and the

knowledge associated with it by enabling consumers to buy food, including fish, in stores, thus freeing them from associated labor and time investments (Ruddle, 1993). As a result, labor-intensive traditional practices, such as shifting cultivation or subsistence fishing, are now practiced only on a reduced scale or not at all. Some respondents considered this trend to be a possible reason for the observed decline in the productivity of gardens.

Access to domestic and especially international labor markets has had a significant impact on the availability of labor for local production (Philibert and Jourdan, 2002). According to Vanuatu's Department of Labor and Employment Services, bilateral labor agreements allowed more than 10,000 seasonal workers from across Vanuatu to work in New Zealand and Australia in 2020. Especially in Torres, but also on other islands, locals reported mainly young men leaving the islands to work as seasonal laborers on plantations abroad. The relatives left behind, especially women, have no choice but to compensate for the loss of labor, resulting primarily in a move away from labor-intensive activities. A woman from Toga, who lived on Hiw at the time of the study, said that "[...] this is an extreme burden for me. During his [her husband's] absence, I have to look after the children, manage the garden, go fishing, or search for wild yam—all by myself." In many cases, there are no remittances, although these would improve the situation of those left behind, for example, by hiring additional labor for gardening. This is partly due to the lack of banking infrastructure. Instead, all the wages are taken home when the workers return. The situation is different for internal migration. Younger people in particular migrate to the economic centers of the country, as these places offer, for example, more diverse educational or employment opportunities than the islands of Torba (Petrou and Connell, 2017). There is a more or less regular exchange of money and goods such as clothing, technical appliances or food between the people who have left and the families who have stayed behind. According to estimates by the National Statistics Office, the share of these remittances (money and goods) in the total household budget in Torba is small, amounting to just over two per cent of total income and just over one per cent of total household expenditure (Vanuatu National Statistics Office [VNSO], 2012). However, our data shows that in some cases remittances are the main source of income. This is especially true for older people who are supported by their families because other livelihood strategies, such as subsistence farming, can no longer be practiced due to advanced age.

Sociocultural Causes

Colonization not only came along with a transition to a monetary economy and the establishment of Western political systems but also with a gradual Christianization and the establishment of Western educational systems (Ruddle, 1993; François, 2012). As a result, new values and norms began to enter Vanuatu society and increasingly shape social cohesion. In this section, we highlight some of these developments and examine how they may have led to the locally observed changes.

New Institutional Structures

The traditional political systems of many states in the Asia-Pacific region were continuously replaced by Western systems during Western colonialism and the years that followed (Ruddle, 1993). In Vanuatu, these transitions and dynamics are particularly complex. During the period of condominium, the Anglo-French government introduced new partially divergent "systems" over pre-existing large varieties of social structures (Miles, 1998). Some of these systems differed linguistically (French or English), while others differed by political or religious aspects. Thus, Vanuatu today is characterized not only by a high degree of traditional cultural and linguistic complexity, but also by the legacy of overlapping colonial languages, educational systems, and churches. This makes it particularly difficult to assign specific aspects of broader sociocultural dynamics to observations in the receiving system.

While the sphere of influence of new political systems primarily affects communities around the economic, and thus colonial centers, the impact on the remote islands was initially minor. According to the study participants, problems and challenges today are still primarily solved locally, and the presence of the central government on the remote islands is hardly felt. According to local communities in Torres, the national government only appears during elections, or increasingly, after natural disasters, to support communities with relief efforts. This support was particularly evident following Cyclone Donna, which devastated mainly the northern islands in spring 2018. Food was provided relatively quickly by the authorities. Despite the gratitude for these relief measures, some study participants also view this support critically: "If we are supported every time there is a disaster, people forget to help themselves. Growing hunger food becomes obsolete, and so we increasingly lose the traditional knowledge associated with such coping strategies" (Hiw, participant observation [informal discussion, translated from Bislama]). A similar dynamic of undermining traditional coping mechanisms through disaster relief has already been observed in other parts of the country after Cyclone Pam (Wentworth, 2020).

More immediate than the influence of Western political systems on local societies seems to be the influence of Christianization. Missionary activities have increasingly led to the displacement of traditional customs and associated local hierarchies and authorities, particularly established male hierarchies (Ruddle, 1993). In Hiw, some study participants from older generations reported that missionaries criticized, or even forbade, their followers from following traditional practices. Many of these practices have disappeared in the decades since, and with them much of the structure and hierarchy that characterized traditional graded society. While some are critical of this, other study participants are glad that at least some aspects of these practices, now considered archaic, have disappeared. Nevertheless, the prestige and standing associated with traditional status remains high, and kinship obligations are still honored (MacClancy, 1981), but the traditional bases of legitimacy are increasingly no longer coercive (Valjavec, 1987).

Time Conflicts

The church has developed into a decision-making and guiding institution that not only brings in new beliefs, but also asks for active engagement, i.e., for fundraising. This concerns not only the church, but also schools. In all communities that we visited, locals either do small jobs or sell garden produce and/or food in favor of either the church or the school. For some, this is the only reason, besides subsistence, why they grow crops in their gardens: “[...] I only sell garden products to fundraise for school or church” (Interview, translated from Bislama, Mere Lava). None of our study participants perceived this as a burden, yet it forced people to compromise elsewhere: “I have a lot of commitments to the community—school, church, or chief—so I tend to neglect my garden” (Interview, translated from Bislama, Mere Lava).

Schools also put pressure on villagers to generate monetary income by charging fees and expenses. Although primary school education is free in Vanuatu, parents still must bear the costs of materials, uniforms, and transportation. In contrast, for secondary education, tuition fees apply. Depending on the province, the type of school administration (governmental or non-governmental), the amount of children per family, and their age, school fees can vary from 23,800–35,000 Vatu, not including boarding fees (Republic of Vanuatu, 2005, 2014; Feeny et al., 2013). According to interviewees, for almost all study participants who had school-age children, school fees, along with the purchase of imported foods, clothing and miscellaneous purchases for household operation, were the largest expenditures in their household. This is broadly consistent with data from the Vanuatu National Statistics Office (Vanuatu National Statistics Office [VNSO], 2012).

New Norms and Values

New economic, religious, and political systems and perceptions have opened new paths and introduced new values and norms that have complemented or replaced the old ones (Valjavec, 1987). This process took place gradually and cannot be attributed to single events. From a local point of view, however, there are events and circumstances, apart from Christianization, that are considered to be particularly proximate causes of the entry of new values and norms. According to some interviewees, Western ideas of what is important and desirable are becoming increasingly adopted following visits or stays in the country's economic centers, e.g., for the purpose of higher education or work, during stays abroad as seasonal workers, or via globalized media content. Tourists as a possible “source of inspiration” were mentioned only rarely and only on islands that are hardly developed for tourism.

These broader sociocultural changes have not only altered the social framework and the scope of action, e.g., in terms of economic strategies, but have also had a significant impact on traditional knowledge (Granderson, 2017). The newly introduced values and norms increasingly decoupled society from spirituality and thus procedural aspects of traditional knowledge production (Walker, 2013). Furthermore, the disintegration of traditional structures has also extinguished traditional knowledge retention. Moreover, schools, and thus Western concepts of education, are also being perceived

in part as places where knowledge and values that do not necessarily correspond to traditional understandings are imparted. Conversely, they are held partially accountable for the replacement of traditional knowledge by Western knowledge. One study participant summarized this development as follows: “Before, there was a very clear way to attain knowledge. Today, people are freer. That is good, but also has its consequences [...] schooling allows everyone to have their own thinking. Before, only the chief knew everything” (Interview, translated from Bislama, Gaua).

DISCUSSION

Individual Choice Matters but Is Embedded Within Broader Global Forces

In line with our hypotheses, factors besides climate change may influence vulnerability to food insecurity. Using the telecoupling approach, we embedded these potential vulnerability factors within broader sociocultural and economic factors that transcend time and space. We thereby recognize the increasing interconnectedness of even remote regions such as North Vanuatu with the global society and economy.

We show that the vulnerability context in North Vanuatu is strongly influenced by individual choices made with the aim of efficiently allocating resources in order to maximize income. This income, in turn, is partially needed to cover the increased cost of living, which is largely made up of school fees and the cost of buying food. The burden of such costs, especially school fees, on the household budget is substantial. Free education, as has been repeatedly mooted in Vanuatu, would significantly reduce this pressure, thereby freeing up resources for other purposes (Savage et al., 2020). Increased food costs, on the other hand, are not primarily due to any external factor but are principally a consequence of changing food preferences toward imported food. However, food preferences vary from island to island. Our findings show that, as already observed by Tzerikiantz (2000) in West Santo, the role of imported food in the local diet depends largely on the remoteness of a given island or community, which limits financial ability to afford these products and their availability in general.

The pursuit of income maximization is often associated with a shift of resources, for example labor, land, or time, away from subsistence practices, such as gardening, toward livelihood strategies that promise greater economic returns, such as cash crop production or tourism. The impact of this shift on livelihood vulnerability, especially to food insecurity, can be both negative and positive.

For example, a reallocation of resources toward market-based livelihoods can lead to greater dependence on market dynamics, such as supply chains and market prices, and thus increase vulnerability. This situation can become particularly critical for food security if alternative livelihood strategies (e.g. subsistence production) are not or no longer available to compensate for income losses or lack of food imports. However, this situation has not yet arisen on any of the islands we studied. Even with a complete absence of income and/or food imports, it is possible

to produce enough food through the gardens and, especially on remote and sparsely populated islands, to fall back on natural food resources, such as fish and crabs. This observation is also consistent with studies on other islands in Vanuatu, such as Malo (Allen, 2001). In addition, the reallocation of resources intensifies competition between market-oriented livelihood strategies and subsistence practices. For example, our results suggest that the observed decline in garden productivity is partly due to resources being diverted away from subsistence gardens. The resulting lack of time or land can lead to a change in gardening practices, e.g. shorter fallow periods or abandonment of shifting cultivation, which in turn can have a negative impact on soil fertility. It is not clear how such changes in practice affects the vulnerability of the gardens to climate change. We see an urgent need to better understand these dynamics, especially with regard to the importance of gardens as food safety nets and the expected aggravation of climatic conditions due to climate change.

Market-based income and food sources not only bring new dependencies and thus increase vulnerability but also have the potential to strengthen resilience to food insecurity. In particular, imported food can also serve as a food safety net that ensures the supply of food even in the event of crop failures, for example due to drought (Allen, 2015). However, a prerequisite for this is a functioning distribution system that guarantees the availability of imported food. While such a system is in place on islands with good transport connections, it is by no means guaranteed on remote islands such as Hiw, Merig, and Mere Lava.

Our study shows that vulnerabilities on the different islands cannot be summarized in a common narrative. Due to the different socioeconomic characteristics of the islands, which, in turn, are related to their geographical location and the associated degree of isolation, the broader socioeconomic dynamics have different influences on the vulnerability context of each island. It may well be that, as argued by Campbell (2009), some of these processes described in this paper have led to increased livelihood vulnerability through new dependencies (e.g., on national and global market dynamics). However, our findings also suggest that the observed changes have enabled additional livelihood strategies that complement existing (subsistence-based) strategies, leading to a reduction in one-sided dependencies and thus an overall increase in the resilience of local livelihoods and more food security. Therefore, we support the conclusion drawn by Allen (2015) that vulnerability in Vanuatu and the Pacific in general needs to be differentiated and that economic development and associated access to markets, in particular, can also lead to an increase in resilience.

Our findings suggest that the observed reallocation of resources and resulting impact on vulnerability is a consequence of new economic realities and is driven by sociocultural changes. These findings confirm other studies that consider economic and, to some extent, social dynamics as possible causes of food insecurity in the region (Feeny et al., 2013; Lebot and Siméoni, 2015; Medina Hidalgo et al., 2020; Savage et al., 2020; Vogliano et al., 2021). Some of these dynamics have their origins in colonialism and, to some extent, the accompanying Christianization of large parts of Vanuatu's society. Moreover, since the 19th century, the country has increasingly become

part of globalized society and, as such, of a worldwide nexus of flows of goods, people, and information (Held et al., 2000; Young et al., 2006). Due to the resulting dynamics and interdependencies (telecouplings) between Vanuatu (receiving system) and sending systems in the rest of the world, decisions by supranational organizations such as the WTO or court rulings in Germany suddenly play a role in the decision-making of local farmers. We believe that it is crucial to better understand these dynamics and interdependencies in order to grasp local realities.

The Telecoupling Framework to Identify Measures for Reducing Vulnerability

The consistent structuring of economic and socio-cultural dynamics along the different elements of the telecoupling framework helped to identify specific dynamics relevant for local vulnerabilities. This, in turn, allows interventions to be optimally adapted to local needs and contexts, thus increasing their relevance and sustainability. Furthermore, the framework promotes an understanding and recognition that interventions are not isolated but are influenced by cross-scale dynamics or potentially lead to cascading effects, some of which may result in unintended consequences (Chignell and Laituri, 2016). For example, our results suggest that a potential measure to increase the productivity of local subsistence gardens, such as the introduction of more productive or resilient varieties, may not harmonize with existing aspirations, such as income maximization. Accordingly, the measure is somewhat at odds with sociocultural and economic trends because more economically attractive options are preferred, and subsistence production does not necessarily harmonize with prevailing norms and values, such as food preferences. In other words, although increasing the yield of subsistence production would lead to more independence from external vulnerability factors, such as price fluctuations, it does not automatically mean that local populations would sustain such a measure.

We had difficulty structuring telecouplings that operate over longer time scales. For example, the establishment of Christian beliefs and the associated introduction of new values and norms began in the second half of the 19th century (François, 2012) and continues to the present day. Over this period, some agents or flows associated with this telecoupling may have lost meaning for today's everyday life or been diluted into other dynamics. Nevertheless, they were the original trigger for current telecouplings or form a basis for today's dynamics. Hence, such cross-time telecouplings and their complexity are difficult to grasp. Therefore, the question of where to demarcate system boundaries and define the temporal and spatial scale of analysis must be answered. The framework almost tempts to analyze the individual components and temporal dimensions in their entirety. This can swiftly end up in a "holistic trap," as Friis and Nielsen (2014) wrote, where "everything ends up being important and connected to everything else."

We attempted to circumvent this by placing local perceptions as the starting point of our analysis, which restricted telecouplings, at least at the receiving systems' end, to what

is locally perceived as relevant. However, this did not help to incorporate divergent temporal and spatial scales, and for example, help to answer the question of whether time conflicts triggered by commitments to the church are telecouplings or whether the church itself is a community-immanent organization. This question is further complicated by the fact that there is not a single church, but that the practice of the faith is carried out by several Christian denominations, some of which can be traced back to more recent missionary activities and not to the initial Christianization by the Melanesian Mission and the Anglican Missionary Organization.

Apart from the difficulty of identifying and timing the senders of flows, we agree with several studies that point to the challenge of clearly distinguishing between sending and receiving systems (Friis and Nielsen, 2014). Flows can be multidirectional and interrelated to each other. For example, the German court that reversed the kava import decision can be considered a sending system because its decision opened up new markets. If we would have placed the focus on the lobbying activities of South Pacific kava-producing countries and marketing authorization holders that prompted the court to reassess the ban and ultimately to revise the ruling (Kuchta et al., 2015), the analysis would have been reversed. This may not be of great importance for the community itself, but it is for the development and characterization of a causal relationship. For depending on the perspective, the implicit power relations also change, with the senders being associated more with active actors and the recipients more with passive actors (Friis and Nielsen, 2014).

We found that the telecoupling approach needs to be tailored to analyze cross-scale interactions as drivers of vulnerability to food insecurity at the local level. One way to do this, according to Liu et al. (2019), is to focus on specific components, such as the receiving system, as we did in our work.

CONCLUSION

Our findings show that policies to reduce vulnerability, e.g., to maintain or improve the productivity of subsistence production, are only likely to be fully effective and sustainable if they are thoroughly adapted to the context of the problem being addressed. For this, a change in vulnerability needs to be conceived both as a product of past processes that may have an impact on the present and as part of a nexus of current bidirectional interactions and processes taking place across multiple spatial scales, i.e., are telecoupled.

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We argued that the concept of telecoupling is a useful tool to capture and better understand the complexity of cross-scale dynamics around a vulnerability context. However, the difficulties in demarcating systems as well as spatial and temporal boundaries pose a major challenge in applying the framework. We still strongly encourage vulnerability scholars to use this tool, both to benefit from its utility and to further improve the framework through their findings.

DATA AVAILABILITY STATEMENT

The datasets generated for this study are available on request to the corresponding author.

AUTHOR CONTRIBUTIONS

DN designed the research, secured funding, led the analysis, and led writing of final version. KK, MS, and PK provided advice on analysis. DN, KK, MS, JS, and PK co-wrote the initial manuscript. All authors contributed to further writing and editing. All authors contributed to the article and approved the submitted version.

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SUPPLEMENTARY MATERIAL

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