John Connell · Kristen Lowitt *Editors*

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Preface

Food security is one of the great issues of our time with all the available evidence suggesting that in most parts of the world climate change is making the challenges of producing adequate food more difficult. At the same time, neoliberal policies related to trade and marketing are not always supportive of food sovereignty, with their effects, in many contexts, being to undermine protections of health, equity, and sustainability.

These changes have particularly affected small island developing states (SIDS) that have weaker economies, are less easily able to adapt to climate change, and where patterns of agriculture and fishing are already changing in response. This book shows how the problems of food security and food sovereignty are a function of distinctive interactions between economic, social, political, technological, and environmental processes. It shows how in so many SIDS food insecurity is not a problem of food production, or even one of food distribution, but a function of livelihood insecurity. Thus, considerable care has gone into thinking about the structures and circumstances that affect livelihoods, how changes might be best supported, and how these relate to wider processes of development.

This book emerges from a special issue of *Regional Environmental Change* in 2015; it has developed the issues that were raised in that initial volume, drawing in more chapters from other SIDS to broaden accounts of food security and ensure coverage of different ocean realms. The chapters explore a range of circumstances from small coral atolls in Micronesia to larger Caribbean states such as Trinidad and Tobago. Collectively they point to the many different contexts of food security, different responses to trade, social change, and technological innovations, and the need for new policies and practices to ensure more secure livelihoods in support of food security and food sovereignty.

We would like to thank all the authors that contributed to this volume, as well as the work of Arlette Saint Ville, Gordon M. Hickey, and Patsy Lewis on the 2015 special issue of *Regional Environmental Change* that was the genesis of this volume.

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Chapter 1
Food Security and Sovereignty in Small Island Developing States: Contemporary Crises and Challenges

John Connell, Kristen Lowitt, Arlette Saint Ville and Gordon M. Hickey

Abstract Small Island Developing States (SIDS) are widely recognized as a special case for sustainable development due to the unique set of challenges and vulnerabilities they face. While SIDS are a diverse group of nations, most share such characteristics as limited land availability, insularity, susceptibility to natural disasters and deep integration into global markets that make them particularly vulnerable to global environmental and economic change processes. Such processes and changes are increasingly playing out in the realm of food security. In this chapter, an overview is given of the key social–ecological vulnerabilities driving SIDS food security in different contexts, including inherent problems of ecology and location; particular trajectories of development where modernity, migration and urbanization have distanced many people from agricultural systems; new structures of trade that have disadvantaged small states and contributed to shifts in nutritional patterns; governance; and the growing significance of climate change. The chapters that comprise this volume are outlined and drawn on to offer new directions for how policy and practice might better support more resilient SIDS food systems.

Keywords Environmental change · Food security · Small island developing states · Nutrition · Health · Trade · Governance

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1.1 Introduction: The SIDS and Food Security

This book provides a contemporary overview of the social, ecological, economic and political vulnerabilities[1] that drive food and nutrition insecurity in different Small Island Developing States (SIDS) contexts, including both high islands and atolls, from the Pacific to the Caribbean. It examines the historical and contemporary circumstances that have accompanied the shifts from a focus on subsistence production to the consumption of imported processed foods and drinks, and the impact of this transition on nutrition and on the rise of non-communicable diseases. It also assesses the challenges to reversing this trend, and how more effective social and economic policies, agricultural and fisheries strategies, and governance arrangements might better support more resilient and sustainable small island food systems. It therefore offers both theoretical and practical perspectives, bringing together formerly distinct policy areas such as agriculture, food and nutrition, commerce, health, planning and socio-economic policy.

SIDS were first recognized as a distinct but diverse group of countries (including some non-independent states) with particular size-related problems and needs at the United Nations Conference on Environment and Development (UNCED) in Barbados in 1992. The United Nations has since classified 52 countries and territories as SIDS, the majority of which are located in the Caribbean and Pacific regions (United Nations 2011). This book primarily excludes SIDS with substantially more than a million people (such as Cuba and the Dominican Republic) where circumstances associated with small size (area and population) and socio-economic contexts are somewhat different. However, the book includes several references to Papua New Guinea, a nation that includes many smaller Melanesian islands with similarities to those of nearby Vanuatu and Fiji.

All SIDS are considered vulnerable to environmental shocks and share characteristics of small size, limited resources and over-dependence on trade (and imports). Collectively, these characteristics exacerbate the challenges of achieving the United Nations Sustainable Development Goals (SDGs) by 2050. Development in SIDS is further affected by high communication, energy and transportation costs, irregular international transport volumes, disproportionately expensive public administration, and scarce physical and skilled human resources that prevent economies of scale, especially in archipelagic states such as Kiribati and the Maldives. SIDS unique challenges are coming under more intense pressure at a time of increasing globalization and environmental change (McGillivray et al. 2010; Ganpat and Isaac 2014; Pelling and Uitto 2001; Scandurra et al. 2018).

One area where the vulnerability of SIDS to global change is increasingly being played out is food security, identified as a priority at the Third International Conference on SIDS convened by the UN in 2014 in Samoa. Already typified by being

[1]In this book, we employ the concept of vulnerability as a "diagnostic tool to gauge the inherent limitations and dependencies of communities experiencing change", while also recognizing that vulnerability is a power-laden concept, with potentially significant implications for the populations being labelled as vulnerable (Haalboom and Natcher 2012).

particularly hazard-prone, by virtue of long coastlines relative to land areas, SIDS are among the most susceptible places to the impacts of climate change. More extreme weather events, sea level rise, stressed water resources due to changes in rainfall patterns, intermittent droughts and acidification of the oceans all pose threats to the agricultural and fisheries resources underlying their local food systems (UNFCC 2007). In recent years, for example, parts of Tuvalu, Kiribati and the Cook Islands have experienced droughts that have necessitated the import of freshwater, while intense cyclones in Vanuatu, Fiji and Tonga in the South Pacific and hurricanes in the Caribbean islands of Dominica and Barbuda have devastated agricultural production. In light of these threats, SIDS across the world have demonstrated leadership in forming global coalitions to ensure climate change becomes a matter of international diplomacy (Ourbak and Magnan 2018; Sealey-Huggins 2017).

Interacting with environmental change processes are inequities in global trade, rising food prices, underdeveloped domestic food systems and limited local food production capacities (Alliance of Small Island States 2012; United Nations 2011). At the household level, food insecurity issues in SIDS are increasingly presenting themselves in the form of high rates of chronic Non-Communicable Diseases (NCDs) including diabetes, strokes and hypertension, spurred by more globalized diets and increasing importation of energy-dense foods (Chase et al. 2014; Francis et al. 2010; PAHO/WHO 2012). Obesity levels in several Pacific SIDS put them in the world's top ten.

Despite the significance of these issues, relatively little research focus has been given to the particular context of food security in SIDS, where natural resources are scarce and residents have limited flexibility in using and developing resources. This is remarkable at a time when the most recent global report of the FAO has indicated that, after a period of decline, world hunger is rising again and, despite arguing that the trend towards food insecurity is due to climate-related changes, gave very little attention to SIDS (FAO 2018, cf. Fanzo et al. 2018).

Generally, SIDS-related food security research has not been particularly well integrated. Research on agricultural intensification, for example, has often had a relatively narrow focus on specific subcomponents of either human livelihoods (such as income), production technologies (such as irrigation or enhanced seed varieties) or of ecosystem services (such as biodiversity). Similarly, studies focusing on the social context of fisheries, including their contributions to food security, are often divorced from studies focused on management and conservation (Chuenpagdee and Jentoft 2018). Consequently, there is a need to improve our understanding of the different social–ecological contexts affecting food security in SIDS across the food system (Blancard and Hoarau 2013; Campling and Rosalie 2006; Campling 2006; Scheyvens and Momsen 2008).

Collectively, the chapters in this book examine the complex and interconnected factors that shape SIDS food systems, at multiple scales, and consider how their adaptive capacity can be better supported to ensure food security. As a starting point for understanding food security, we use the 1996 Food and Agriculture Organization definition which states: 'Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life'. This definition is commonly further broken down into the dimensions of food access, availability, utilization and stability (FAO 2008). Food security is a central component of the United Nations Sustainable Development Goals (SDGs) with agricultural intensification of a key strategy for ending hunger while achieving gender equality, reducing poverty, increasing health and well-being and the sustainable use of marine and terrestrial ecosystems.

Increasingly, discussions concerning food security have broadened to also include social issues such as the roles of culture and identity, community well-being, sustainable livelihoods and food as a human right (see Holt-Gimenez 2011). This has led to the concept of food sovereignty, which brings greater attention to the politics of food security, with questions of governance, power and justice at the forefront (DeKeyser et al. 2018). Food sovereignty asserts that all people have the right to food, that democracy is fundamental to this realization and that decisions about food systems, including markets, forms of production and food cultures, should be made foremost by the local people who depend on them (Wittman et al. 2011; Patel 2012; Fairbairn 2010). Food sovereignty is often understood as key to achieving food security and is particularly relevant to SIDS because of their generally high dependence on trade and often limited involvement in production (Paddock and Smith 2018).

It is important to acknowledge that the concepts of food security and food sovereignty are fluid, changing and generally complementary, with the former being more neutral on power relations and the latter focused much more on who controls the means of production (Gordillo and Jeronimo 2013). We therefore draw on both concepts in our discussion of the food system challenges and issues facing SIDS to inform and identify areas requiring further research and policy attention. We now turn to introducing the major themes of the book, organized in terms of the key factors influencing food security in SIDS, and present the chapters that comprise this collection. We conclude by considering how policies and governance responses might be better integrated into support of more resilient small island food systems.

1.2 Major Themes of the Book

1.2.1 Modernity, Culture and Convenience: Social Change and Declining Food Systems Diversity

Important regional and local differences exist between SIDS that have contributed to variations in the structure and role of governance. Hence, these chapters identify a range of factors and different patterns of development that have given rise to food and nutrition security challenges. Virtually throughout the SIDS, there have been a range of historical trajectories of change, loosely and more recently conceptualized as globalization. Such drivers of change include colonialism, decolonisation, missionization, trade, transport, migration, urbanization and the ascent of multiple modernities. Necessarily their impact has varied enormously according to the location of SIDS, their size, resources, climate, cultural distinctiveness and colonial policies. However, all SIDS have been shaped in some way by both internal facets of geography and culture, and by the variable influences emanating from beyond. In many cases, globalization has meant a subsequent weakening in systems of food self-provisioning, and most recently a decline, even in some cases a complete collapse, of export-oriented agricultural production systems.

These distinctive directions and their regional variations are described in several chapters in this volume. Campbell (Chap. 3), Connell (Chap. 4) and Saint Ville et al. (Chap. 9) all provide important insights into the consequences and relevance of history for SIDS food security in the form of underdeveloped domestic food systems, high reliance on energy-dense food imports and diet-related health problems. Saint Ville et al. (Chap. 9) further argue that Caribbean SIDS are struggling to break out of an engrained export-oriented agricultural policy framework which limits their ability to support and develop diverse domestic smallholder farming systems despite the collapse of traditional export commodity markets. Mauritius and Sao Tome and Principe are in the same position.

Particular challenges to food production and food security exist in some places disadvantaged by geography. Coral atolls offer poor soils where plant diversity is limited, and often experience natural hazards such as wind and wave erosion. Despite often productive lagoons, and a diversity of marine species, food shortages are not unusual (and accounted for significant mobility in pre-contact times). Difficulties are accentuated where population densities are high and households have only limited access to land. Small atolls have been particularly disadvantaged. The Carteret Islands, Papua New Guinea (PNG) have experienced food shortages of varying severity, especially since the 1960s, associated with a steadily growing human and pig population, the increased use of coconuts for copra to generate income, and land shortages that have given rise to outmigration (Connell 2016). The particular problems of achieving food security on Eauripik (Federated States of Micronesia. FSM), one of the smallest and most densely populated atolls in the Pacific, are well described by Scourse and Wilkins (Chap. 5), and more generally described for the five Micronesian SIDS by Connell (Chap. 4).

In contrast to the difficulties experienced by residents of coral atolls, high islands offer much greater potential for food production based on better soils, diverse ecologies, access to land, lower population densities, and usually fewer natural hazards. However, there as elsewhere, pressures on land exist, local people have shifted from subsistence to cash crop production, food imports have become significant and diets are increasingly dominated by imported processed foods often high in fat, sugar and salt, leading to an increase in obesity and diet-related NCDs. Allen's account of agricultural change and nutrition on Malo island, Vanuatu (Chap. 6) is typical of recent changes in villages in many Melanesian SIDS that are neither particularly remote nor experiencing a marked urban influence but experiencing nutritional shifts characteristic of most SIDS.

Despite the drivers of modernity and globalization, most SIDS populations remain in rural areas and agriculture and fishing provide valuable livelihoods. In addition, agriculture and fishing contribute a significant proportion (sometimes the entirety) of exports, generate lease fees (in fisheries), enable local market provision and are the key to food security and nutritional well-being. Subsistence-based economies in SIDS have lasted longer than in many other parts of the world, especially in the Pacific and surviving best in the Melanesian SIDS of Solomon Islands and Vanuatu.

Yet, diversity of land and sea production is declining, as even remote people have absorbed a cash economy ignoring traditional staples and importing food from distant places. In several island contexts, agricultural work has been disparaged as demeaning and unworthy (Connell 2013). A shift away from traditional staples poses particular problems for food security after natural hazard events. Root crops such as taro are more resistant to cyclones, hence when Fiji experienced a series of cyclones in the mid-1980s there was a greater subsequent dependence on imported foods than might hitherto have been expected since less labour-intensive taro was being planted (Chung 1987). In some places, such as in Kadavu (Fiji), 'a rich tradition of agrodiversity persists in adversity … because of geographic isolation and a scarcity of profitable export commodities' (Kuhlken 2007: 72). However, there and elsewhere, the persistence of a distinctive agricultural system has been as much 'the product of an externally imposed political economy more than of conscious resistance' (Bayliss-Smith et al. 1988: 8). The considerable difficulty of securing a middle ground between achieving the retention and promotion of local 'traditional' foods and balancing this with imported foods, which may be costly but offer status with negative nutritional consequences, is a ubiquitous health and economic challenge. However, despite the vulnerabilities SIDS face, Allen (Chap. 6) reminds us that a narrative of a decline into food insecurity should not be equally applied to all SIDS. Based on the changing context of Malo (Vanuatu), Allen found considerable evidence of resilience in the island's food system, as communities forged locally appropriate solutions to food insecurity and sustainability challenges by adapting their traditional practices and institutions to new global realities.

At the household level, a suite of interacting factors helps to explain why some have managed to maintain adequate access to nutritious food. Shah et al. (Chap. 12) look at the factors influencing household food security in coastal wetland communities of Trinidad and Tobago in the context of intensifying climate change. In general, households that are more food secure in SIDS have relatively good access to useful land, which enables a range of food plants, and access to income through the sale of both export crops and fresh produce, which usually means a short distance to markets. Access to local food markets offers the ability to earn income from the sale of fresh produce as well as purchase foods in local stores, enabling more diverse consumption possibilities. Challenges are significant where surpluses do not exist, markets are remote and transport and storage is difficult (see Schandl et al. 2011), and limited incomes reduce the options available for purchase. While the chapters in this volume largely focus on food security at household, island and national levels, important intra-household variations can also occur. For example, in Timor-Leste, men invariably take some degree of precedence as described by Wong et al. (Chap. 14).

1.2.2 Environmental Management

Management of natural resources and the capacity for local involvement in governance is also of central importance to food security in SIDS, with management practices, and their absence, varying considerably across islands. In the case of small-scale fisheries, the widespread existence of traditional fisheries protection strategies (such as closed seasons, restricted areas and constraints on techniques) is indicative of the perceived need for conservation in the past (at times of smaller populations and greater necessity for self-reliance). Social change and diverse market pressures have meant that in many cases conservation practices have disappeared, even in relatively remote areas. At the same time, management practices have come under increased pressure with sustained entry into the cash economy, increased capacity for exploitation through improved gear technology (e.g. nylon nets, spear guns, snorkelling masks, waterproof torches), changing social, political and demographic circumstances, weakened leadership, and reduced respect for customs (Winthorpe 2004; Connell 2013). In Fiji, it has been suggested that young people place less value on management and view the sea through a commercial rather than 'traditional' lens (DeMers and Kahui 2012). Blasting has killed off significant proportions of reefs in some areas. Necessarily, therefore, there is also potential for positive innovations in fisheries management at the community level as described by McConney et al. (Chap. 11).

Pressures on inshore fisheries are greatest around growing urban areas, especially where the poor take advantage of this economic and subsistence resource, where populations are in flux and regulatory regimes ineffective or absent in a leadership vacuum. This has often resulted in conflicts over access to marine resources and fishing grounds, the failure of marine protected areas and reduction in species availability (Aswani and Sabetian 2009; Cinner 2009; Baker et al. 2015). Fishing has become less productive around some urban areas, such as around the towns of Gizo (Solomon Islands), Majuro (Marshall Islands) and Funafuti (Tuvalu) where lagoons have become polluted and where overfishing occurs (e.g. McCubbin et al. 2017; Paddock 2017). Perhaps unusually, subsidies and loans from government and from the national development bank have exacerbated overcapacity and overfishing in Fiji, eventually pushing even experienced fishermen below the poverty line (DeMers and Kahui 2012). In the Galapagos, overfishing, species decline, ecosystem stress and distance to ports are correlated (Edgar et al. 2010). On parts of Upolu (Samoa) and in Rodrigues (Mauritius), declines in inshore fish catches have been attributed to sedimentation of reefs as a result of deforestation (including mangrove removal) and agriculture, a situation certainly more widespread. Likewise, management of lagoon and oceanic fisheries has come under pressure. Pressures are likely to increase further with the continued rise of a middle class, especially in Asia, associated with greater demands for fish consumption.

The impact of many different pressures on inshore fisheries has been poorly documented, but it has been predicted, at least for the Pacific Islands, that over the period 2010–2035:

> the amount of fishery products originating from coastal fisheries that is accessible to urban residents will decline sharply due to overexploitation and habitat destruction. A growing proportion of the population will not be able to catch sufficient fish to provide for household consumption, and purchased fish will become relatively expensive. Food security issues will grow tremendously in importance (Gillett and Cartwright 2010: 7).

This scenario is probably already in place in several Caribbean SIDS, as it appears to be in Rodrigues (Mauritius), where weak enforcement of fisheries regulations and a lack of income generating alternatives 'have created a history of noncompliance and degrading fisheries' (Peterson and Stead 2011: 2). Geographical variations in the extent of depletion of inshore fisheries are considerable, with some of the greatest decline of inshore fisheries experienced in Caribbean SIDS, strongly associated with population density, increased fishing and human impacts on reefs. Larger fish, once abundant in the Caribbean, are increasingly absent from high-density areas, especially in the Antilles, but remain near uninhabited islands. Larger fish are more likely to experience declines since they are targeted by fishers, mature more slowly and often form aggregations, which increases their vulnerability. The consequence of shortages is higher prices beyond the reach of many urban people.

In addition to fisheries, pressure on forests has accentuated; biodiversity has declined sharply and wood has gradually become a commodity. In large parts of PNG, including south Bougainville (Connell 1978), hunting and gathering have declined considerably in recent times because of the destruction and pollution of habitats, the availability of superior technology (guns) and extirpation of some species. Land grabs have been common in several prime coastal areas, not least in Vanuatu, taking agricultural land out of production and fundamentally challenging local food sovereignty. Consumption of wild foods has also declined in some areas because 'bush foods' are associated with subsistence lifestyles and the 'denial of social and economic progress' (Paddock 2017: 104). Nonetheless, the diversity that wild foods offer can be invaluable for nutrition. Chapters 14 and 15 offer unique insights into wild food consumption in Timor-Leste, among the poorest of the SIDS. In a study on maternal and child diet diversity, Wong et al. (Chap. 14) found nutrition to be superior in villages where hunting and gathering in forest areas remains possible. Erskine et al. (Chap. 15), based on surveys and interviews of household wild food consumption over a 7-year period, found that when garden foods are scarce, wild foods provide a greater degree of food and nutrition security.

1.2.3 Knowledge and Linkages

New structures of education, a decline in local leadership and a greater dependence on distant governments have combined to reduce the extent and use of traditional environmental knowledge in many SIDS, whether of fishing seasons, famine foods or strategies for management of resources. In most SIDS, environments have been degraded, local food security reduced, traditional mechanisms and practices for coping with hazards disregarded, and external dependence increased. In Woleai

(Federated States of Micronesia (FSM)), for example, when hazards such as cyclones devastated islands, people once turned to preserved and stored foods or sought assistance from their 'traditional partners' on other atoll islands or on more distant atolls. In similar contemporary disasters, islanders now turn to Yap state or the FSM government for support (see Connell, Chap. 4).

Hazards have contributed to shifts in food consumption where critical shortages have been remedied by relief supplies of modern foods. For example, this meant that during the 2012 drought on Niue, most families lived on imported food, including potatoes, rice, flour and biscuits, stimulating growing reliance on them (McNamara et al. 2015); rice consumption in PNG similarly increased rapidly after the 2016 drought (see Campbell, Chap. 3). Simultaneously, as access to disaster relief exists, local people no longer plant and maintain 'famine foods' or engage in processing and storage of foods, and knowledge of such practices disappears.

A decrease in varietal diversity has occurred in many places as part of a wider process of agricultural disintensification, or simply the abandonment of intensive agricultural practices (such as both irrigation of taro and taro pits and the replacement of taro by less nutritious cassava). This has reduced the amount of labour devoted to agriculture. Taro production and cooking is widely seen as drudgery. Disintensification occurs for a number of reasons, including the replacement of a subsistence economy by a wage economy, loss of agricultural labour and production as a result of migration, the introduction of trade stores and store-bought foods (discussed more in the following section), the replacement of human labour by machinery, and access to higher yielding crops or species (Manner 2008; Boyd 2001; Umezaki et al. 2000; Gaillard and Manner 2010; da Costa et al. 2013). By contrast, resilience is a characteristic of many traditional agricultural systems, but commercialisation has gradually eroded the social significance of many traditional crops, as islanders have moved closer to the commercial economy.

On some islands where export-oriented agriculture dominated for centuries, traditional knowledge about crop production was also eroded. This gap in knowledge has recently become particularly acute for some farmers in Caribbean SIDS as export-oriented structures have collapsed and they find themselves having to reorient their livelihoods around smallholder production for domestic markets (see Lowitt et al. Chap. 10). While some farmers had some experience in tending gardens for their families, the knowledge and skills required to run a small, independent farm as a viable business is a new venture. Saint Ville et al. (Chap. 13) provide insights into how social learning may be fostered among smallholder farmers in St. Lucia, looking particularly at the role of social capital. Local knowledge has also been changing in some places with regard to accessing other resources, such as water, that are vital for food production. On limestone Vatulele Island (Fiji), which occasionally requires freshwater supplies from the main island, McInnes (1986: 132–3) suggests that run on

> dependence on the central government is in fact the result of national, responsible decision-making. With regard to water resources, dependency is sanctioned and encouraged by government action and is culturally a legitimate strategy that is effectively no different from former island network relationships.

Ironically, local mechanisms for management and self-reliance have been devolved upwards, from the local ‘private sector’ to a distant but flagging public sector. In multiple ways—chosen and imposed—islands are increasingly part of a wider world and the loss of knowledge tied to food security is often part of that loss of connection to place.

1.2.4 A World of Imports

While food security is threatened by changing production practices, land losses and environmental degradation, as described above, it is threatened just as much by changing tastes and the availability of new imported foods. The transition from food production for local consumption to the production of commodities for export has been long established, notably in Caribbean SIDS where sugar and later banana plantations historically took up valuable land, and opportunities for domestic food production were correspondingly limited.

Changing nutrition is partly associated with declining local food production and reduced crop diversity, but also by low incomes, the inability to purchase adequate diets (at high market prices), a growing dependence on store foods, disdain for cooking (and agricultural labour), and the poor quality of cheap, readily available, imported processed foods and drinks. In some eyes, exclusive consumption of local foods even hints at poverty, while status and prestige are gained from the consumption of imported foods. In many SIDS, the taste preferences of children have contributed to shifts in consumption, with their preferences for softer, sweeter foods, such as two-minute noodles, sweet biscuits, bread and rice rather than taro and cassava.

Imported foods range from corned beef, turkey tails and meat flaps to instant noodles, biscuits and soft drinks (e.g. Grossman 1998; Evans et al. 2001; Dixon and Jamieson 2005; Cassels 2006; Oles 2007; Foster 2008; Gewertz and Errington 2010; Rudiak-Gould 2009, 2010; Thow et al. 2010; Seiden et al. 2012; Wichman 2012), a function of cost, status, taste, convenience and accessibility. Frozen foods, from chickens to ice cream and soft drinks, increasingly filter into rural areas. Tinned fish is a remarkably common import in many island contexts, with imported fish and meat preferred to local versions (e.g. Potter and Sluyter 2010; Dixon and Jamieson 2005). In Woleai (FSM), where more than 200 species of edible fish inhabit the lagoon, the best-selling item in most stores is tinned fish, a situation typical of many atoll contexts in Micronesia and elsewhere (see Connell, Chap. 4). In most such contexts, as in the plantation systems of the Indian Ocean and the Pacific, workers were given imported foods—notably rice and tinned meat and fish. Rice quickly became a staple in many island societies and accounts for numerous, mainly unsuccessful, efforts to produce rice in SIDS.

Even in the most remote places, stores are dominated by imported goods, mainly tinned foods. Rice and flour have become food staples, sometimes eaten without accompaniments when incomes are short (Schwarz et al. 2011; Rudiak-Gould 2009). On Vatulele (Fiji), more than a third of store goods were foods and more than half of them came from outside Fiji (McInnes and Connell 1988), much as in Martinique, where 'the products on its dusty shelves form a startling microcosm of the world system, an astonishing testimony to the history of colonialism and the more recent organization of international commerce' (Price 1985: 119). Imports, especially food, have embedded islanders in wider worlds. The humble village store is the ubiquitous symbol of globalization.

Moreover, the ability to purchase and consume imported foods can function as a powerful symbol of modernity, status and the 'good life', with some of these 'new' foodstuffs—such as rice, mutton flaps and noodles—firmly incorporated into household consumption, exchange relationships and ceremonies (Errington and Gewertz 2008). In pre-war Siwai (Bougainville, PNG) when very little else had changed, it was extremely prestigious to be able to incorporate rice in traditional feasts. Through imported foods, individuals are connected with and experience the outside world, and become powerful through their association with money and modernity (Hess 2009; Dundon 2004). Typically, compared with previous generations, the percentage of store-bought foods has steadily increased, as cash becomes more available and tastes of household members are habituated to it.

The transition to the consumption of imported food became more rapid as internal migration and urbanization occurred. Migrants had less time for food production and many had at least some ability—and need—to purchase food, as access to urban land was unavailable. Even in primarily rural contexts, as in PNG, the transition was rapid and symbolized in the title of books such as *From Kaukau* [Sweet Potato] *to Coke* (Jeffries 1979). That transition posed problems. Some urban residents were unable to pay the high price of market produce and only able to afford cheap imports of lesser nutritional value, or to go without food on occasion. Many urban residents grow food where they can but, as towns have grown larger, such possibilities declined as agricultural land was converted into other uses, especially where tourism (and such infrastructure as ports and power stations) contributed to a coastal squeeze that simultaneously made urban areas more vulnerable to hazards. In towns such as Port Vila (Vanuatu) urban residents either travelled longer distances, at some cost, to produce food or simply gave up (Petrou in press). However, by choice and necessity, urban agriculture and home gardening has survived, even in such unpropitious and densely populated places as the coral capitals of Tarawa and Funafuti (East and Dawes 2009). Yet, in both these urban centres, it is currently almost impossible to find anything more than bananas, breadfruit, coconuts and fish for sale, hence, fresh food commands high prices. Urban nutrition is therefore particularly problematic because of limited access to garden land, low incomes (which limit access to local produce which can be expensive) and the relatively low cost of imported foods. Many imported foods are less costly than local fresh foods, and thus consumed by the relatively poor. These changing patterns of food consumption and poor nutrition have paralleled an epidemiological transition towards 'lifestyle diseases of modernisation', known as non-communicable diseases (NCDs). The health problems associated with NCDs are discussed below.

1.2.5 Trade, WTO and Political Economy

A free flow of trade facilitated by the World Trade Organization (WTO), along with global investments in industrial agriculture, has been significant in contributing to shifts in relative food prices that favour animal-source foods, edible oils and other global commodities, including sugar. Combined with more open borders, this has resulted in food imports being available in the most isolated islands of the South Pacific, with rice, biscuits and canned fish and meat replacing traditional foods.

Agricultural policy development in the SIDS is based on neoliberal trade policies facilitated by the WTO that have disadvantaged small local producers through competition with cheaper food from industrial agricultural systems (Saint Ville et al. 2015). Economic and trade liberalization reforms beginning in the 1980s have had the effect of reducing domestic controls on trade and import tariffs which are important to protecting smallholder farmers in SIDS (Ford et al. 2007). As Lowitt et al. (Chap. 10) discuss, supporting collective action among farmers can help improve their market access and make them less vulnerable to liberalizing markets (Devaux et al. 2009; Markelova et al. 2009).

Throughout the SIDS, food and beverage imports are consistently high, often being more than a third of the value of all imports, contributing significantly to trade imbalances. Further, the inability to retain policies banning inappropriate imports, as WTO regulations are enforced (see Barnett, Chap. 2), may worsen nutrition and health among low-income groups, and can be seen as an erosion of food sovereignty. For example, Samoa's accession to the WTO in 2011 meant that it was no longer able to impose a ban on turkey tails and other problematic imports, despite the nutritional and health advantages (Thow et al. 2010; Snowdon et al. 2011). Some have suggested that the accession process itself is inherently flawed given the power imbalances between existing and acceding WTO members, and the resultant diminished control over food supplies and food security (Hughes and Lawrence 2005; Tigerstrom 2005).

Alongside trade imbalances, almost without exception SIDS are characterized by high levels of migration, both to urban centres and internationally. The MIRAB[2] model of Pacific Island micro-economies explains limited economic activity in SIDS unmanaged by public policy as a result of high import leakage from tied foreign aid and international remittances (Bertram and Watters 1985). In some Pacific SIDS, such as Samoa and Tonga, remittances have become the single greatest component of national and household incomes. While remittances can play a critical role for households to gain access to resources, the overall trend is for remittances to contribute little to self-reliance and food production. Remittances are characteristically initially directed to high levels of welfare provision, including the purchase of foods (Connell and Conway 2000). They have thus tended to discourage local production, especially where the migration has been that of the productive labour force, but have smoothed out consumption, reduced household vulnerability and led to improved food security

[2]MIRAB is an acronym for migration (MI), remittance (R) and foreign aid (A) and the public bureaucracy (B).

(Thow et al. 2010). Food transfers through remittances are also bidirectional and have contributed to the retention of some local foods (Petrou and Connell 2017). The combination of migration and remittances has resulted in the decline and abandonment of staple foods in parts of Micronesia and St. Vincent, but not in Jamaica (see Connell, Chap. 4; also Thomas-Hope 2017), with consequent social, economic and environmental costs. Further research is needed to examine the nexus of migration, remittances and food security in the context of climate change. The need to build adaptive capacity and enhance food security in light of climate-induced changes requires improved understanding of these interconnected issues because these economic and climatic shocks may lead to worsening conditions for the poor and vulnerable.

1.2.6 Health, NCDs ('Diabesity') and the Economics of Choices

The trends in trade and political economy discussed above intersect with processes of modernity, urbanization and environmental change to influence health outcomes in SIDS. Most SIDS have experienced an epidemiological transition from infectious diseases to NCDs, a transition most advanced in the Caribbean but of enormous significance in the Pacific. Especially amongst the urban poor, people are turning to cheaper but less nutritious food imports. Poverty partly explains such shifts, as 'any government that heavily taxes these [imported] products or bans them will suffer the ire of the working poor at elections and so the issue is largely avoided' (Grynberg 2010: 34). In Kiribati, the former President, Ieremia Tabai, has observed, 'if the shops are without rice and sugar it is a big political issue' (quoted in Connell 2013: 87).

NCDs have been exacerbated by various facets of urbanization including a more sedentary life, lack of recreational facilities and open space, combined with increased alcohol, soft drink and tobacco consumption, especially in contexts of inadequate education and housing, lack of access to clean water and sanitation, overcrowding, and poverty (e.g. Calvert-Faamoe et al. 1997; Cameron 1997; Christensen 1995). Cardiovascular risks follow more sedentary and suburban lifestyles, bureaucratic employment and commuting by vehicle rather than by bicycle or on foot—even in flat cities such as those in atoll states –where underinvestment in public transport exacerbates the problem. Some of the greatest nutrition and health problems are experienced in informal urban settlements.

These resource-poor environments have been noted as fostering 'anatomical, hormonal and physiological' changes on foetal development that results in the intergenerational effects of poor nutrition with consequences of obesity, NCDs and long-term health impacts (Popkin et al. 2012; 4). This epidemiological transition has increased the already high per capita healthcare costs and reduced the effectiveness of health care in small states historically targeted at tropical and communicable diseases. Changing diets and more sedentary lifestyles have resulted in NCDs reaching epidemic proportions in many states (Connell 2013; Inaoka et al. 2007). This is especially so in Micronesia (see Connell, Chap. 4). The Secretary-General of the SPC, Dr. Jimmie Rogers, has declared that NCDs are a greater threat to the Pacific region than sea level rise (quoted in Connell 2013: 148). In Samoa, almost 53% of adults are obese, 23% have diabetes and 21% high blood pressure; the cost of sending patients overseas for treatment was estimated at about $4.5 million in 2011, while costs within Samoa were significantly greater (Radio New Zealand International, 15 November 2011). In the Caribbean as well, hypertension and diabetes are a substantial economic burden in states such as the Bahamas and Barbados (Abdulkadri et al. 2009).

Linked to poverty, urbanization, tourism, greater mobility and migration, and renegotiation of sexual identities, HIV/AIDS is slowly increasing in most SIDS, a challenge not easily amenable to policy formation (Connell and Negin 2010). The combined rise of NCDs and HIV/AIDS poses a challenge to health services in most SIDS since many health services are usually weak, under-resourced and understaffed, with high staff turnover, and NCDs are costly and labour-intensive to treat. Health services are particularly weak in smaller SIDS, such as Niue (Connell 2007). Linked to poverty, suicide rates are also high in several SIDS, especially the Marshall Islands and Fiji where in 2011 incidence reached an 'epidemic level'—the second highest rate in the world—especially amongst Indo-Fijians in the sugar cane belts of the west and north, where poverty was increasing (Radio Australia, 7 November 2011).

Given the close interconnections among trade, social marginalization and health, the most effective interventions are not usually specific health and nutrition interventions but are policies that reduce the extent of poverty and ease up time for exercise and, especially for children, for play, and also that seek to reform the terms of trade. However, putting in place these types of integrated policies is a challenge, to which we turn in the next section.

1.3 Governance and (Elusive) Policy Formation

Concerted efforts to develop and implement effective integrated rural and regional development policies have generally been lacking. It is not only in the Caribbean that 'the policy of most governments on fisheries has appeared to be in token form' (Walters 1984: 95). One explanation for this gap may be the cultural mismatch and lack of common understanding between rural communities and national policymakers (elites) (Rahman et al. 2017). Rural bias and decentralization of services in favour of fisheries, agriculture and integrated rural development is nearly implausible. Households themselves have had to diversify to achieve development, as has occurred even on small, remote islands (Turner et al. 2007; Wilson 2013). Just as many individuals have moved out of agriculture and fisheries, where they could, in favour of other economic activities (or, in some cases, into unemployment), so governments have not always looked favourably on rural people. In Mauritius, for example, there was reportedly an 'island-wide mentality to view traditional fishermen with contempt and blame their distress and misery on insufficient volition and salubrity' (Paul 1987:144). Cook Islands agricultural workers have been similarly denigrated

(Alexeyeff 2008). In St. Lucia, the cultural and linguistic gap that separated bureaucrats from farmers saw the latter viewed as illiterate, ignorant and incapable of innovation (Moberg 2008: 89–90).

Throughout the SIDS, the evidence strongly indicates that where households have some access to off-farm livelihoods, and thus a greater diversity of income sources—especially where this contributes to gender empowerment and to employment during village food shortages—nutrition is likely to be substantially better. That is particularly true in continental states where access to employment opportunities can be superior, as in Ghana (Kuwornu et al. 2018); that is less easy to achieve, especially in the smaller more fragmented SIDS, but not unattainable. Where women's roles have changed with some forms of empowerment, in terms of greater economic agency, access to physical capital and greater gender parity, food security and food sovereignty are more likely to be achieved (FAO 2014; Patel 2012; Sharaunga et al. 2016). Consequently, several chapters in this volume focus on the need for more effective government policies and practices, both related to the greater inclusion of women in every phase of food production and marketing (see Wong et al., Chap. 14) or the provision of better infrastructure, such as feeder roads and electrification, either to gain access to markets or to store fresh foods (see Pilling et al., Chap. 8).

Many of the chapters in this collection also suggest that experimenting with more decentralized governance may help increase SIDS adaptive capacity to global change and improved food security. In many SIDS, hierarchical governance structures developed during earlier colonial periods are increasingly ill-suited to coordinating responses to food insecurity. The chapters by Saint Ville et al. (Chap. 9), and McConney et al. (Chap. 11) argue that the high level of centralized power held by state institutions is constraining the capacity for agricultural system innovation and collective action at local levels. This likely contributes to a situation in which communities feel disempowered as they look to the state for leadership, while working connections among citizens and between citizens and institutions remains weak. At the same time, the chapters by Connell (Chap. 4) and Lowitt et al. (Chap. 10) highlight that centralized state institutions have been inadequate on their own in advancing action on resilient food and nutrition security outcomes due to the complexity of the challenge.

Moreover, as conservation and management of resources has become ever more critical, it is evident that this is not always occurring at the local level for a range of reasons, principally as population pressures on scarce resources increase and traditional knowledge is ignored. The need to value farmers' knowledge within agricultural development efforts and support more peer-to-peer knowledge exchange among farmers is addressed by Lowitt et al. (Chap. 10) and Saint Ville et al. (Chap. 13). Challenges are also evident in such areas as food storage that pose technical and infrastructure problems. Post-harvest food losses pose problems in many contexts, all too evident in Underhill et al. account of the problems of getting food to Samoan markets (Chap. 7), emphasizing the need for good transport and storage infrastructure. More general support for marketing initiatives is an ongoing need for SIDS, and one that may be addressed, at least in part, by enhanced collective action among farmers as explained by Lowitt et al. (Chap. 10).

More decentralized governance structures may also be able to make better use of and rebuild the local knowledge relevant to natural resource and food production issues, while bringing decision-makers and researchers closer to those communities most affected by global change processes (Lemos and Agrawal 2006). This may help to build the types of social capital among citizens and institutions crucial for empowering citizens to participate in local development (Helling et al. 2005). Thus, Lowitt et al. (Chap. 10) examine the factors influencing the innovation potential of smallholder farmers in four Caribbean SIDS. They identified access to markets, financing and knowledge networks as constraints to innovation, but found that important social interactions were missing, despite these being required to create an enabling environment for innovation (Klerkx et al. 2012). Specifically, they observed a pervasive lack of trust among smallholder farmers and other actors in the agricultural system that prevents collective action and coordination on food production-related issues and ultimately erodes their capacity to respond to economic and environmental shocks. McConney et al. (Chap. 11) identified a lack of participation in fisheries management decisions by resource users that contributes to conflict in the industry and weakens its capacity to adapt to sustainability challenges. Paralleling the findings by Lowitt et al. in the smallholder agricultural sector, they also identify a lack of trust operating among fish harvesters and between fish harvesters and formal institutions that undermined their capacity to meaningfully communicate and participate in governance processes.

The chapters in this collection provide some practical examples of how such decentralized structures may work to enhance the resilience of SIDS food systems. For example, McConney et al. (Chap. 11) argue for greater participation of fisherfolk, through well-organized social networks in fisheries management to enhance the capacity of these structures to respond to sustainability challenges. Shah et al. (Chap. 12) examine the factors influencing household vulnerability to food insecurity in the face of extreme weather events in the Caribbean country of Trinidad and Tobago. They found that household socio-demographic characteristics and livelihood strategies are strongly related to food security, but that the level of resilience provided by these factors is significantly reduced in the face of climate variability. Accordingly, they urge that community planners, policymakers and residents need to work together to develop sustainable national food systems that are less vulnerable to extreme weather events. Lowitt et al. (Chap. 10) suggest that innovation platforms may be useful for bringing together and building trust among actors at different levels of the agricultural innovation system.

At the same time, governance needs to address specific and pressing policy needs, including financing and providing supporting infrastructure to enable market access, ensure that prices are reasonable, and in a broader sense to develop national economies where households have reasonable incomes and effective purchasing power. Well-meaning policies directed to the consumption of nutritious local foods are unlikely to be successful without prices being at least comparable. Imports of cheaper food (such as rice, tinned fish and chickens) to feed the growing urban populations put pressure on local production and distribution systems which cannot compete. Thus, neoliberal trade policies as facilitated by the WTO place barriers in the way of food security and undermine food sovereignty.

Finally, climate data are thin in SIDS and climate models cannot easily simulate change where islands and oceans are intertwined. Traditional agricultural systems that have coped in the past with climatic hazards (such as using mixed planting, mulching and famine crops) are steadily disappearing and may not, in any case, be able to cope with the more extreme circumstances of future events. Resilience to risks associated with climatic variability and extreme events depends on adaptation and coping strategies at local, subnational and national, and transnational levels; key to the ability of farmers to adapt to climate variability and change will be access to relevant knowledge and information. Ultimately, the ability to adapt and cope with climate change will be a function of the specific circumstances and governance, at various scales. It is likely that migration out of agriculture will be one partial response to climate change where that makes agricultural production more difficult. Since taking up off-farm employment and reliance on remittances have enabled some households to escape poverty, as they have done in Micronesia (see Connell, Chap. 4) this is likely to continue, and even accelerate, under climate change.

1.4 Conclusion

Food systems in SIDS are unusually complex and vulnerable to a range of external drivers such as climate change and global market volatility. This has brought with it new and emerging food security and food sovereignty challenges as SIDS struggle to provide nutritious foods to their citizens because of a now familiar conjunction of environmental degradation, increasing reliance on imports, changing tastes and ultimately changing climate.

Recent conceptualizations of food systems, in addition to production, processing, trade and consumption of food, include ecological sustainability, social drivers of consumption and global change, and climate change, all integral to policy interventions, and all constantly changing. Choice, politics, economics and culture have important roles in determining activities and outcomes in SIDS food systems. SIDS present a special case for sustainable development and for food security and food sovereignty as global and regional economic and environmental change often has disproportionate and inequitable impacts on small island communities. This can have very serious implications for household food and nutrition security, affecting the sustainability of fishing and farming systems and the health of the island populations that depend on them for food, nutrition and livelihoods. Sustainable intensification of agriculture—and of fisheries—are seen by many as flagship strategies to achieve global food security, yet the chapters in this book both demonstrate just how difficult that can be to achieve but also some of the strategies that offer solutions. Indeed, some forms of agricultural intensification may increase production, but at the same time have negative impacts on ecosystems, or benefit only better-off producers.

The various chapters in this collection point to a pressing need for food systems innovation in different SIDS contexts in order to promote food security and more local control over food systems. SIDS food systems are at a critical juncture as intensifying economic and environmental change is making learning, adaptation and innovation in institutional structures crucial. This will likely involve embracing more decentralized governance approaches capable of empowering actors, building capacity and developing social capital in support of collective action, coordination and learning. However, barriers to response and effective change include cultural differences between local knowledge and 'modern' science, lack of political and technical support, and the capacity of small numbers of bureaucrats to implement policies (Latu et al. 2018).

Thus, achieving food security for island communities needs to be not only about knowledge and theory but also about practice. Research partnerships that engage scientists as well as local practitioners and community members may help contribute to better contextualized and 'socially robust' knowledge (Nowotny 2003), while also fostering the community relationships especially important in a SIDS context where relatively low levels of trust and cooperation in agriculture and food systems often exist. Indeed, 'genuine and durable partnerships' for promoting sustainable development was the theme of the Third International Conference on SIDS in 2014 (UN 2014). The Samoa Pathway, a series of resolutions adopted at this Conference, affirms international cooperation and multi-stakeholder partnerships for research and development as a critical component of advancing action on sustainable development, including agricultural research and food security (UN 2014). This requires a more integrated approach that recognizes food security as a human right, with priority given to the most vulnerable—especially children, adolescent girls and women—and a greater focus on nutrition-sensitive agriculture and food systems in ways that support local self-determination and food sovereignty.

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Chapter 2
Climate Change and Food Security in the Pacific Islands

Jon Barnett

Abstract Climate change poses diverse risks to the food security of individuals and communities in small Pacific Island states and offers a challenge to human rights. Climate change is likely to emphasize contemporary environmental trends and problems, ranging from land degradation, deforestation and the loss of biodiversity, to coastal erosion and the pollution of lagoons. Climate change will adversely affect food systems in the region, including the supply of food from both agriculture and fisheries, the ability of countries to import food through reduction in incomes and damage to infrastructure for food distribution, and the ability of households to purchase and utilize food. If tourism is also affected by climate change national and household incomes are likely to decline, fisheries may be first affected because of climatic impacts on coral reefs and sea temperatures and the mobility of marine species. Reduced agricultural production may be both long-term and short-term outcomes of particular climatic shocks, especially cyclones, with threats most likely to follow particular events rather than the outcome of mean changes in temperature or sea level. Coral atolls, and the atoll states of Kiribati, Tuvalu and the Marshall Islands, are most at risk. Cyclones are likely to become more frequent and reduce the ability of food systems to recover. In multiple ways, climate change puts at risk the very basic and universal need for people in Pacific SIDS to have access to sufficient, safe and nutritious food at all times.

Keywords Small islands · Agriculture · Fisheries · Development · Vulnerability

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2.1 Introduction

This chapter explores the risks that climate change poses to food security in the islands of the Pacific. Its focus is, for the most part, on social systems and the people who shape and are shaped by them. This is, in a sense, a kind of 'bottom-up' perspective, informed not so much by abstract models of climate and biophysical systems, but by the author's understanding of the everyday processes that make and remake social life in the region. This is useful because it shifts the focus of analysis to existing vulnerabilities to climate as a basis for determining future vulnerabilities—the importance of which has been stressed by Ford and colleagues (2010).

2.2 The Pacific Islands

There are 22 island states and territories in the South Pacific, the combined population of which is 11.3 million. Of these, 8.1 million reside in Papua New Guinea (SPC 2018). Population growth, particularly in the Melanesian countries, is high, and these countries additionally have considerable rates of rural-to-urban migration.

The total land area of all islands in the region is approximately 550,000 km^2, which contrasts markedly with the region's combined exclusive economic zone of some 30×10^6 km^2 (Overton 1999). The largest country is Papua New Guinea with a land area of 462,000 km^2, while the smallest is Tokelau with only 12 km^2. The Melanesian countries are, generally, large and mountainous with fertile soils and mineral resources. The Polynesian and Micronesian islands vary in type from smaller volcanic islands to low-lying coral atolls. Almost all of these islands are small, although they often have extensive reef and lagoon systems that provide a considerable amount of protein to communities. Kiribati, the Marshall Islands, Tokelau and Tuvalu are comprised entirely of low-lying coral atolls. In all countries, capital cities and most other major urban centres are situated on the coast, and most or all critical infrastructure is located in the coastal zone.

Gross domestic products in the region are low, ranging from US$ 10 million in Tokelau to US$ 19 billion in Papua New Guinea (Pacific Community 2018). GDP per capita is consequently similarly low in most countries, ranging from US$ 1,500 in Kiribati to US$ 31,000 in New Caledonia. Kiribati, Samoa, the Solomon Islands, Tuvalu and Vanuatu are currently classified as least developed countries. Tourism is an important industry in some countries, accounting for up to 47% of GDP in Fiji and Vanuatu, and 22% in Kiribati and Tonga (Cheer et al. 2018). All countries receive income from licensing fees paid by foreign-operated fishing boats operating within their territorial waters, and that accounts for up to 40% of GDP in Kiribati and Tuvalu (ADB 2018). Primary industries account for less than 30% of formal GDP in all countries in the region, and in most countries their share is less than 20%, though these figures belie the large contribution agriculture and fisheries make to the informal economy and livelihoods (UNDP 2014).

Nine of the region's countries and territories are fully independent. Six are self-governing and constitutionally independent, but with some form of association with either the United States or New Zealand. Seven are dependent territories either of France, the United States or New Zealand. These political ties influence aid flows and income from remittances. Most of the smaller Polynesian and Micronesian economies are heavily dependent on aid. In the Federated States of Micronesia, Kiribati, the Marshall Islands, Nauru, Niue and Tuvalu aid accounts for at least one-third of GDP. Remittances sent from migrants living overseas (largely in Australia, New Zealand and the United States) are also important. In 2016, remittances accounted for 10% of GDP in Kiribati, 12% in Tuvalu, 14% in the Marshall Islands, 15% in Samoa and 28% in Tonga (World Bank 2017), though the real value of remittances in all countries in the region is probably far larger than these estimates.

Pacific Island societies contend with an array of environmental problems, including land degradation, such as soil nutrient depletion and soil loss; deforestation due to logging for timber exports, clearing for agriculture and fuelwood collection; biodiversity losses across a range of terrestrial and marine flora and fauna; depletion of freshwater resources through saline incursions and contamination from urban, agricultural and industrial sources; and coastal and marine degradation, including coastal erosion, coral loss and coral bleaching, contracting artisanal fisheries, and pollution of lagoons (Connell 2013). These environmental problems increase the vulnerability of ecosystems to the effects of climate change.

2.3 Regional Scale Changes in Climate

Projections of the possible changes in climate in the Pacific Islands region apply to the region as a whole and not to specific countries, because the grid squares in general circulation models are between 200 and 600 km^2, which provides insufficient resolution for the land areas of almost all the Pacific Islands. Projections from an ensemble of global models give some indication in the range of changes in rainfall, temperature and sea level that may be expected in the region relative to the period 1986–2005, given modest increases in greenhouse gas emissions in the future (which are taken from the IPCC Representative Concentration Pathways, specifically RCP4.5). These models suggest that by the end of the century in the Southern Pacific air temperatures will have increased by between 1.1 and 1.5 °C, annual precipitation will have increased by up to 4%, and sea levels will have risen by between 0.5 and 0.6 of a metre (Nurse et al. 2014). A 32 cm rise in sea level is considered to have serious implications for the continued viability of ecological and social systems on low-lying coral atolls (Pearce and Teuatabo 2000). These projections may be conservative given both the possibility of higher concentrations of emissions and observations of temperature and sea level increases that suggest higher rates of change in recent decades (Lough et al. 2011; Nurse et al. 2014).

However, mean changes are perhaps less indicative of future risk than variations in extremes of temperature, rainfall, winds and sea levels, which are all likely to increase in coming decades (Nurse et al. 2014). For example, with precipitation it is less the mean annual changes, but rather the frequency and intensity of rainfall events that matter most, particularly given that the region is prone to floods and droughts. Water for agriculture is almost entirely supplied by rainfall rather than by irrigation systems. More rainfall is expected in summer—which is the wet period in the region—and there may be less rainfall in the already dry months. This has implications for sustaining crops throughout the year. Rainfall events are also likely to be more intense, and possibly less frequent, with implications for flooding and drought events (Nurse et al. 2014).

The risk to coral atolls, and to coral systems throughout the region, is a function not just of rising sea levels but also of rapid changes in sea surface temperature which cause coral reef mortality through coral bleaching. Evidence suggests that tropical sea surface temperatures have been rising over the past 50 years, with an increase in extremes of sea surface temperatures associated with increasingly severe bleaching episodes, and is currently rather faster than hitherto expected (Hughes et al. 2018a; Resplandy et al. 2018). Kench et al. (2005) suggest that undisturbed reef systems may persist under conditions of rising sea levels and rapid increases in sea surface temperature, and that it is human disturbances on reefs that make them vulnerable to climate change. Bleaching of reefs causes erosion of shorelines through changes in sedimentation. It also impacts on artisanal fisheries and is a factor in ciguatera fish poisoning (Hughes et al. 2018b; Hales et al. 1999).

Associated with these projected changes in temperature, precipitation and sea level are projected changes in regional climate system s and extreme events. Of particular importance to development in the region is ENSO, which in El Niño years brings drought to most of the region. For example, the 1997–1998 El Niño caused widespread drought and subsequent food shortages in the islands west of the international dateline. Agricultural losses in Fiji were valued at US$ 65 million, and some 260,000 people in Papua New Guinea were in a life-threatening condition due to depleted food supply (WMO 1999). In Niue, the 1983 El Niño resulted in a 60% decrease in mean annual rainfall, forest fires and a dramatic fall in agricultural exports and a dramatic increase in food imports. Modelling studies suggest that climate change may double the frequency of El Niño events in the future (Cai et al. 2014).

The ENSO phenomenon has a significant influence on tropical cyclone frequency and possibly also on intensity. El Niño years tend to increase the frequency of tropical cyclones in islands to the east of the international dateline. While the relationship between climate change and tropical cyclones is still highly uncertain, there is evidence that they may become more intense in the future—meaning that such cyclones may last longer, exhibit higher wind speeds and unleash more rainfall (Walsh et al. 2016). In many Pacific Islands, cyclones are a cause of mortality and injury. They also cause massive financial losses. For example, in recent years, Cyclone Pam which primarily struck Vanuatu in 2015 caused 11 deaths and damages equal to about 60% of GDP, and Cyclone Winston which struck Fiji in 2016 caused the deaths of 44 people and $460 million in damages (Finau et al. 2018; Handmer and Iveson 2017; Marto et al. 2018).

In 2004, Cyclone Heta in Niue destroyed 43 houses that were more than 25 m above sea level, as well as the national hospital, national museum and the nation's bulk fuel storage tanks (Government of Niue 2004). As well as wind damage, and damage from increased rainfall and flooding, cyclones induce storm surges which can reach up to six metres in height, and, in the case of cyclone Heta in Niue, waves in excess of 30 m in height. Barker (2000) goes so far as to argue that in Niue cyclones have powerfully shaped the structure of contemporary society through their effects on out-migration and aid dependence.

The possibility of increases in the frequency and intensity of such hazards, rather than changes in mean conditions, poses the most immediate danger to Pacific Islands. Barnett and Campbell (2010) suggest that a critical factor for social–ecological systems in the region will be a decrease in the return times of extreme events, which in turn will reduce the ability of systems to recover, causing long-term declines in welfare. These changes in extremes will be compounded by changes in mean sea level, temperature and rainfall, and both these changes in extremes and mean conditions pose dangers to the Pacific Islands through their impacts on agriculture, fisheries, health, food security, economic development and population movements. Of these, the following discussion is limited to the issues of food production and food security. In terms of food production, the focus is on the two most important local sources of food for most Pacific Islanders—agriculture and fisheries.

2.4 Impacts on Agriculture

In most Pacific Islands, agriculture is primarily conducted for subsistence purposes, and in some cases for sale to domestic and international markets. For the most part, the value of agricultural exports is small relative to imports. Few households meet their own food needs entirely through their own production but rely in part on markets for at least some of their food needs.

Agricultural production in the Pacific Islands is likely to be adversely affected by climate change in a number of ways. For coastal communities, the effects of erosion, increased contamination of groundwater and estuaries by saltwater incursion, cyclones and storm surges, heat stress and drought may individually or in combination undermine food production. Cyclones are a significant cause of lost agricultural production, for example, Cyclone Ami caused over US$ 35 million in lost crops in Fiji in 2003, and 13 years later Cyclone Winston caused over US$100 m in crop losses (McKenzie et al. 2005, FAO 2016). Drought presents problems to agriculture everywhere in the region, particularly given the lack of irrigation. The increased risk of flooding in river catchments also threatens food production, for example, severe flooding of the Wainibuka and Rewa Rivers in Fiji in April 2004 caused damages to between 50 and 70% of crops (Fiji Government 2004). Increasingly intense rainfall events, coupled with ongoing processes of deforestation and longer dry spells, may all impact on soil fertility.

The effects of climate change on critical infrastructure may also undermine agriculture for both subsistence and commercial purposes. Damage to equipment for processing and storing food can undermine the effective supply of food and damages to roads, rail and vehicles due to storms and cyclones can disrupt the supply of goods to markets, undermining the livelihoods of rural growers. Large-scale economic changes can also undermine food production. Impacts on production in key sectors such as tourism, and increasing public expenditure on repairing and replacing lost infrastructure may all have impacts on employment and incomes. This in turn could suppress demand for locally grown foods sold in local markets.

Traditionally Pacific Island communities grew multiple crops, which tended to confer some resilience in food supply as not all crops were affected by specific hazards such as a drought or cyclone (Campbell 1990; Elmqvist 2000). Repeated attempts to develop monocultural cash crops such as copra, coffee and sugar cane, combined with the effects of the cash economy and penetration of markets with often cheaper if less healthy foods, have all served to weaken the diversity and intensity of local production in many places. The effects of these changes have been increased dependence on the market for food, decreased resilience of food supply in the face of hazards (given low incomes and relatively high food prices) and a ‘nutrition transition’ in the region associated with increased rates of obesity and cardiovascular disease (Popkin et al. 2001). Food aid in response to droughts has been shown to further increase dependence on poor quality foods and hasten the nutrition tradition (Ahlgren et al. 2014).

These changes are all functions of increased penetration of international markets and of development assistance of various kinds, as well as increased urbanization and in some cases, decreases in security of land tenure (Colding et al. 2003; Clarke and Thaman 1993). The problem is that these attempted shifts towards modern agricultural economies and, more generally, affluent industrial societies have failed to deliver the kinds of resilient agricultural and food systems that developed countries enjoy, whilst at the same time undermining the resilience associated with traditional, agricultural systems. Vulnerability is then manifested in the seemingly permanent transitional nature of Pacific societies.

2.5 Impacts on Fisheries

Given that the ratio of land area to sea area in the Pacific region is 1:300, it is not surprising that fisheries play a critical role in food supply and economic development in the Pacific Islands. Fish is an important source of protein for most coastal communities in the Pacific (Bell et al. 2009). Per capita consumption of fish in the region is very high by global standards, with an average of 70 kg of fish being consumed per person per year across the region in the early 1990s (Gillett et al. 2001). Fisheries also provide income to many coastal communities who harvest shellfish and shells, corals, crustaceans, marine plants, finfish and other species. Inland freshwater fisheries are also important sources of food in Papua New Guinea, the Solomon Islands and Fiji.

In terms of economic development, the value of landed tuna caught in the waters of the Western and Central Pacific ocean is approximately US5.8 billion, with a final market value of approximately US$ 22 billion (FFA 2015; Galland et al. 2016). Of this, around 80% is caught in the Exclusive Economic Zones of Pacific Island countries, although only about 10% of this catch is landed in the Pacific Islands (FFA 2015). Most of the fish caught is by distant water fishing nations, which pay Pacific Island governments some US$270 million a year in access fees (FFA 2015). These fees are an important source of government revenue, accounting for up to 40% in the case of Kiribati, and over 10% in the Federated States of Micronesia, Nauru, Tokelau and Tuvalu (Gillett 2009).

Fishing is very important to the economies of some countries, accounting, for example, for 56% of GDP in Kiribati and 26% in the Marshall Islands (Gillett 2009). For some countries, including Kiribati, Tuvalu and the Solomon Islands, remittances sent home from workers on fishing boats are also important. Gillett et al. (2001) estimated that the industrial tuna fishery accounts for up to 25,000 jobs in the region, while subsistence fishing is critical to livelihoods of up to 20 times that number of people.

Fishing is a combination of luck and skill. Pacific Islanders are highly skilled at fishing, with many societies having a rich body of traditional knowledge about where and how to catch fish (see for example Hooper 1983; Johannes 1978). There is considerable uncertainty about the effects of climate change on the artisanal fisheries upon which many Pacific Islanders depend for food and income. It is important to note that increasing temporal and spatial variability in fish abundance caused by the degradation of reefs and mangroves, and the turbidity, salinity and temperature of water due to climate change is possible. These changes extend the abilities of Pacific Islanders to sustain fish catches. The effect of increasing variability in abundance may affect nutrition and the incomes of coastal populations dependent on artisanal fisheries. It may also increase the time and fuel costs associated with catching fish, with opportunity costs for other livelihood strategies.

In terms of the tuna fishery, changes in ENSO conditions cause variations in catch per unit of effort rates across the South Pacific (SPC 2006). If climate change causes ENSO events to become more frequent or more severe, then this may in turn affect the amount of fish caught in the Exclusive Economic Zones of the equatorial Pacific Islands and the revenue they earn from access fees paid by distant water fishing nations. Climate change may also cause an extension of the present range of tuna to higher latitudes, a decrease in net productivity, increase variability in the catches and so decrease catch per unit of effort with subsequent impacts on the costs of production and prices, and potentially increase pressure on the most valuable species of bigeye and yellowfin in an attempt to offset increasing costs (SPC 2006).

Increases in storm damages due to climate change in the region may also impact on fisheries development through damage to and loss of boats, boat launching facilities, fuel facilities, and fish storage and processing facilities. For example, Cyclone Heta which struck Niue in 2004, caused severe damage to sea tracks from which fishermen launch canoes, as well as to both the derricks used for lifting small vessels into and out of the water, with the result that subsistence fishing ceased for some weeks. So, through changes in fish habitats, migration patterns and in fishing-related infrastructure, climate change poses significant risks to fisheries and to the people and islands that depend on them for food and income.

2.6 Impacts on Food Security

Food production, as specifically identified in Article 2 of the UNFCCC, is only one component of food security. Food security is defined as a situation 'when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary and food preferences for an active and healthy life' (FAO 2002). Food security has three components: food availability, ability to access food and the ability to utilize food.

There are macro- and micro-dimensions to food security. Macro-dimensions include issues such as the total supply of food in country and the prices of food, which is a function of local production and imports. In as much as common illnesses in developing countries, such as malaria and gastrointestinal disorders, impede a body's ability to effectively utilize food, then public health issues associated with water quality and disease control are also important. The ability of people to purchase food is also a function of markets for local products and labour, including the costs of labour relative to the costs of food. Micro-issues include the ability of a household to grow its own food, or to purchase food, and the health of people as this affects their ability to effectively utilize food. People's food needs include a sufficient supply of calories, protein and micronutrients, and so the types of food that can be accessed are also important for food security.

There is also a temporal dimension to food security. People who are poor may be chronically food insecure—meaning they consistently consume insufficient amounts of food. People may also be generally food secure, but vulnerable to periods of food insecurity arising from, for example, disasters undermining their own production for subsistence purposes and for sale to markets, or sudden changes in food prices and/or wages. When large-scale food crises occur—as they still do in parts of Africa—it is the chronically food insecure who are most at risk of death.

Because food security is a function of food production, economic growth and employment, poverty and public health, it is perhaps a far better indicator of 'dangerous' climate change than 'food production' as mentioned in Article 2. For this reason, the possible impacts of climate change on food security in the Pacific Islands should be considered.

In the Pacific Islands at present the situation with respect to food security is not as serious as in parts of South Asia and Africa, in large part because poverty is generally not as acute. There are problems with micronutrient deficiencies in many communities where access to an adequate range of healthy foods is restricted by either local growing conditions or the types and costs of foods available on the market. A part of the problem here is that penetration of local markets by imported foods has resulted in the importation of cheap, poor quality foods of little nutritional value. This results in increasing rates of non-communicable diseases such as obesity, diabetes and heart disease.

However, there are signs that food insecurity may increase in the future (Sharma 2006; Bell et al. 2009), and, when considering the possible impacts of climate change in the region, an increase in food insecurity is a distinct possibility. Climate change may negatively impact on each of the broad determinants of food security—namely food production, economic growth and poverty, and health.

Bell et al. (2009) posit that the current dependence on fish by many Pacific communities leaves them vulnerable to food insecurity in the future. The coastal fisheries available in most states do not currently have the capacity to provide more fish to meet the needs of future population growth and urban migration, and so rural fish consumption will decline as population increases. The risk of overfishing may be increased by pressure on rural communities to use their resources for income generation as well as subsistence. In conjunction with changes to the availability of fish as a result of climate change, there is an urgent need for the diversification of supply in order to make rural communities more resilient to climate change and extreme events, and help rebuild overexploited fisheries resources.

Across the region, there has been in the last 10 years a decline in per capita food production and an increase in dependence on imported foods (Sharma 2006). In all countries, almost all cereals are imported and imports of cereals have steadily increased since 1991, exports of food products have decreased, and trade deficits have increased (Sharma 2006). Declining per capita food production is a function of population growth; insufficient private and public investment in agricultural production; limitations on production due to water scarcity and effective scarcity of land (due to absolute shortages, or insecurity of tenure discouraging capital investment); increasing costs of inputs relative to the value of production; disasters; and rural-to-urban migration. Total food availability in the Pacific Islands, then, is increasingly becoming a function of the ability to pay for food imports.

The ability to pay for food imports at an aggregate level is a function of national income, and so assessing the impacts of climate change on food security in part involves assessing its impacts on the ability of Pacific Island countries to pay for food imports as populations grow. The impacts of climate change in labour markets in New Zealand, Australia and the United States could adversely affect countries which are dependent on remittances, but the impacts are highly uncertain. At least for those Pacific Islanders working in agriculture and agriculture-dependent industries, there may be grounds for concern as these industries in donor countries may also be impacted by climate change. Nevertheless, the assumed higher capacity to adapt to climate change in the developed donor countries would seem to insulate the Pacific Islands against declines in remittances due to climate change.

For those island countries that are heavily dependent on aid, the impacts of climate change on the capacity of donors to sustain aid flows, and the motives for those flows, are also important. The general aid to the countries in the region is delivered for numerous reasons varying from country to country, including for strategic, historical, constitutional, economic and humanitarian reasons. Assessing the impacts of climate change on these kinds of flows is beyond the scope of this chapter; however, we might surmise that the strategic and historical/constitutional reasons for giving aid are relatively independent of the effects of climate change. Economic reasons may change depending on the distribution of economic impacts within and among donor countries, and that aid for humanitarian reasons may increase as climate change results in more damages due to disasters and increasing poverty.

This discussion of aid flows and remittances and their likely changes is simplistic and uncertain, but it does go to show that some of the more important factors in the economic impacts of climate change in many Pacific Island countries concern changes outside of those countries, and that climate change may have little impact on the ability of those countries that are dependent on aid and remittances to purchase food imports. Yet, this tentative conclusion assumes that these extra-territorial flows will increase as demand for them increases due to population growth, rising expectations and increasing costs due to damages caused by climate change.

There may be some significant costs to island economies due to climate change. For example, the World Bank (2001) has estimated that by 2050 damages from climate change could cost Tarawa atoll in Kiribati US$ 8–16 million, or 17–34% of current GDP. Another study estimates that the economic impacts of climate change on Pacific Island economies may be 'so profound that they dwarf any strategic issue currently confronting a major peacetime economy' (Hoegh-Guldberg and Greenpeace Australia Pacific 2000). Disasters such as cyclones and droughts already have significant costs suggesting that increases in their intensity or frequency in the future will place further demands at both donor and household levels to substitute for lost crops, income, infrastructure and housing.

The region's other main source of income, aside from agriculture, fisheries, aid and remittances, is tourism. Tourism, too, is sensitive to climate change. Impacts on tourism have yet to be seriously examined, but it is believed that the industry may be affected directly, for example, through the loss of beaches, and indirectly, for example, through milder winters in traditional markets, reducing the motivation to take vacations abroad (Becken 2005). Extreme events will also be increasingly costly for tourism infrastructure and may dampen demand for travel to the Pacific Islands. Potential tourists may fear for their safety. If climate change results in the spread of malaria and dengue fever to tourist-dependent countries such as the Cook Islands, Palau and Fiji, then this too may decrease demand as tourists may seek alternative holiday destinations. Rising airfares, due to increasing fuel costs associated with potential policy measures to implement the Kyoto Protocol and post-Kyoto agreements, coupled with increasing scarcity of jet fuel, may also undermine demand for tourism.

So, some of the region's main forms of income generation—agriculture, fisheries and tourism–are likely to be adversely affected by climate change. It follows then that employment in these sectors may also suffer, either through long-term contraction in the number of jobs, short-term fluctuations and/or increasing casualization of jobs in response to increasing variability in production, or through downward pressure on wages as employment opportunities decrease and demand for jobs grows due to population growth. The impacts of climate change on these key sectors may also have other important secondary effects. For instance, not only farmers' livelihoods are at risk from climate change but also those whose livelihoods depend on agricultural production, such as input, transport, information and credit suppliers. Impacts in one sector may, in turn, impact on others. For example, declining incomes from agriculture may cause migration to urban areas, increasing urban poverty and placing increasing demand on urban services such as running water, disease prevention programmes and health care. If climate change results in economic contraction and increasing unemployment, then the ability of small island states to provide these services may also weaken, further exacerbating poverty and food insecurity.

Thus, through its impacts on agriculture, fisheries and tourism, climate change may increase levels of chronic and transitory poverty, and, subsequently, decrease the ability of households to purchase food. This, coupled with potential impacts on household food production for subsistence purposes, suggests that not only may per capita food availability contract due to the combined effects of climate change on domestic production and the ability to pay for food imports, so too may the ability of people to access food.

Finally, it is important to consider the impacts of climate change on health as this too affects food security. In most countries of the region, people are relatively healthy compared to other developing regions of the world. Nevertheless, there are problems of undernutrition in parts of Melanesia, and in some of the more remote islands in a number of countries. Malaria is a major cause of illness in Melanesia, and across the region outbreaks of dengue fever occur. Disasters also cause injury and loss of life, and there are problems of diarrhoea and other water-borne diseases such as cholera in a number of islands and in urban areas. Incidences of Ciguatera (fish poisoning) appear to be increasing. Climate change may extend the spread of malaria and dengue fever as the factors that encourage the breeding of the mosquitoes that carry these diseases are influenced by climate. Warming in Papua New Guinea, for example, is likely to cause a contraction of the cooler malaria-free zone in the highlands. There are also demonstrated positive associations between temperature increases and diarrhoea, and between warmer sea surface temperatures and Ciguatera outbreaks (Singh et al. 2001; Hales et al. 1999). Heat stress, increased injuries and deaths from extreme events are also likely to result. Finally, the health services in most Pacific Island countries are ill-equipped and already struggling to cope with existing health problems. They are, therefore, unlikely to be able to adequately respond to the increased health burden of climate change.

Many rural Pacific Islanders are simultaneously engaged in some sale of products or labour for cash, as well as gardening or fishing to meet a proportion of their own food needs. In some cases, hunting is also undertaken (Meleisea 1996). This confers some degree of food security, as it means one or two of these activities can still meet basic food needs. This diversity of livelihood strategies in part explains why in even the poorest communities severe disasters do not result in mass mortality. The risk to food security is that climate change may cause chronic and or sporadic contractions in the food people access through agriculture, fisheries and the market, creating in turn chronic and transitory food problems. These problems of access, coupled with possible increases in illness due to climate change, mean that climate change poses real risks to food security in the region.

2.7 Conclusion

In the Pacific Islands, climate change seems likely to impact on agricultural production for both subsistence and commercial purposes, undermining both local availability of food and the ability of people and societies to purchase food. The impacts on production may be both long-term declines and short-term variations. The other major sector of food production in the region is fisheries, which, like agriculture, supports domestic consumption as well as domestic and international trade. Climate change may also have negative impacts on fisheries, although the nature of change may be less one of mean declines in abundance, but rather increasing variability of supply. Thus, even considering the criteria of food production, climate change is dangerous to the Pacific Islands. Yet it is the compounding effects on the systems that determine food security in the region and thus the larger cause for concern. Through its impacts on production, the ability of countries to import food and the ability of households to purchase food, and human health, climate change puts at risk the very basic and universal need for people in the islands to have access to sufficient, safe and nutritious food at all times.

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Chapter 3
Development, Global Change and Food Security in Pacific Island Countries

John R. Campbell

Abstract While islands have been identified in numerous discourses as being highly vulnerable, food security was a cornerstone of many traditional Pacific Island societies from inland and coastal communities in large islands with considerable natural assets to those that occupied extremely small, low-lying atolls with little or no soil and limited water resources. This was sustained through agroecological biodiversity, the production of surpluses which enabled food preservation and storage to be practiced and underpinned networks of exchange and mutual support that were particularly important during the times of hardship, such as disruptive extreme natural events, including the use of resilient crops and 'famine' foods. Colonisation, the introduction of new religions, the spread of capitalism and most recently the context of globalisation have seen many of these practices decline, and even disappear, as crop diversity has been reduced (making way for export products such as copra). Food storage and preservation are now rarely practised, resilient crops have been replaced, famine foods have lost their importance in the face of disaster relief and many traditional networks have declined. Food imports have become critical, not only in growing urban areas but also in rural communities. Key challenges face Pacific Island countries in order to revitalise those traditional elements of food security in ways that are likely to find acceptance in contemporary society and enable them to adapt to the effects of climate change.

Keywords Pacific islands · Food security · Climate change · Transnational networks · Disasters

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3.1 Introduction

Pacific Island countries (PICs) (see Fig. 3.1) are becoming increasingly dependent upon imported foods; this dependency is not new and was observed in the mid-1970s when most countries in the region were still colonies (McGee 1975). Yet Pacific islands were not traditionally closed systems and ample evidence exists that interisland exchange underpinned food security in many parts of the region (Campbell 2006). However, with the advent of colonialism, and later globalisation, this interdependency has to a large extent been replaced by dependence upon food products imported from outside the region. In recent decades, there has been a significant change in Pacific Island dietary patterns, particularly in urban areas that have resulted in increasing incidence of nutrition-related morbidity in areas such as hypertension, diabetes and obesity. This chapter focuses on these issues particularly as they relate to environmental change. It first examines traditional systems of sustaining food security, particularly in the face of environmental extremes, and in a number of cases under conditions of considerable resource scarcity, and then outlines how these have been modified during the overlapping colonial, independence and globalisation eras. Modifications have reduced the resilience of Pacific Island food systems and may place many Pacific Island communities in positions of considerable vulnerability to the effects of climate change; hence, the chapter concludes with an exploration of ways in which contemporary food systems might become more resilient and thus respond to the threats of climate change on island livelihoods.

3.2 Pacific Island Environments

Great diversity exists within the Pacific region, across island geology, climate and biogeography, through social systems, cultures and economies. Islands have experienced a variety of colonial histories and different forms of incorporation into global economic systems. From an environmental perspective, Pacific islands may be categorised into four types. The first are continental type or inter-plate islands formed along the subduction zone (often referred to as the Pacific rim of fire) on the boundaries of the Pacific and Indo-Australian continental plates. The largest of these islands is New Guinea (about half of which is in the PIC region as part of Papua New Guinea), which is the second largest island in the world, and most other large inter-plate islands constitute the main Melanesian islands of the Western Pacific. These high islands, located close to biological sources in Asia and Australia, and in the usually warmer and wetter western part of the Pacific, have much greater biodiversity and resource availability than other PICs.

The other three island types, often grouped together as oceanic or intra-plate islands, lie to the east and north of the rim of fire and owe their origins to island building volcanic activity as the Pacific plate moves over hot spots in the earth's mantle. The three broad island types are volcanic high islands, atolls (formed as

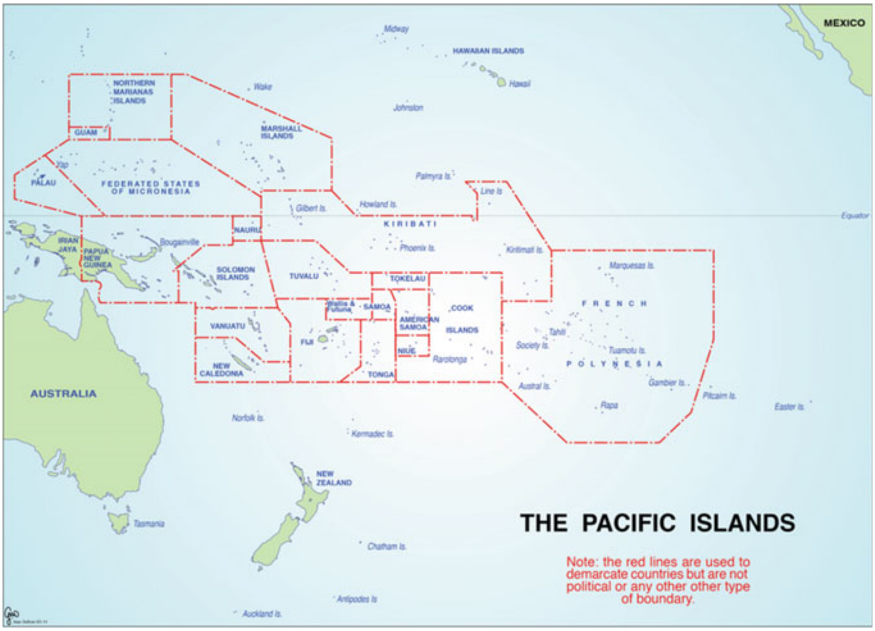

Fig. 3.1 The Pacific Islands

the high islands are eroded) and raised limestone islands (atolls left stranded above current sea levels). Volcanic high islands usually have poor porous soils and poorly developed hydrological systems, and have less biodiversity than the larger islands of the Western Pacific. Orographic rainfall, delivered to the islands by the easterly trade winds, is the main source of freshwater, since surface water is lacking. The final category is atolls, which are roughly circular rings of low-lying islets of wave-deposited sand on coral reefs surrounding a lagoon. They have virtually no soils, very low levels of biodiversity and are dependent upon convectional rainfall. A critical resource is the Ghyben–Herzberg freshwater lens, lying below the atoll surface effectively floating on denser saltwater that has permeated the coral base of the atolls.

Pacific Islands are exposed to a range of environmental extremes—geological, biological and climatic. Under such extreme events, food security is most tested for many PIC communities. Tropical cyclones and drought events are most frequent but geological extremes may also affect food production, such as where landslides triggered by earthquakes destroy gardens. Maintaining food security in these different milieux required different approaches, but across most of the Pacific there were more similarities than differences in modes of food security, notably where ecological differences enable exchanges of goods between communities with different resource bases.

3.3 The Effects of Climate Change

Developing projections of climate change effects in the PIC regions is rendered difficult by the small size of islands in relation to the scale of the models used to generate climate change scenarios. This discussion is informed by the regional assessments of climate change conducted by the Australian Bureau of Meteorology and Commonwealth Scientific and Industrial Research Organisation (ABM and CSIRO 2011; 2014) and the report of the IPCC AR5 Working Group II on Small Islands (2014). Climate change affects the Pacific Islands in various ways; some islands are more exposed than others, or experience different impacts, threatening community security and the capacity of PIC environments to provide adequate livelihoods, involving land security (the protection of the physical basis for settlements and livelihoods), livelihood security (food security and access to other forms of income) and habitat security (safety from harm and exposure to disease). Land security (the existence of land on which to live and conduct livelihoods) may be diminished or even lost in the face of sea level rise, river bank flooding (from increased incidence of heavy rainfall events) and erosion. The places most at risk are atolls, coasts and river floodplains and deltas. Many parts of the region are exposed to drought events including the PNG Highlands and most atolls, with loss of potable water supply (both quality and quantity) impinging on habitat security and reduced agricultural production threatening livelihoods. Changes in tropical cyclone frequency and/or magnitude, and changing disease vectors, increase stresses on habitat security. Other effects include changing sea surface temperatures and ocean acidification that may cause degradation of coral reef ecosystems and fisheries, key elements of PIC livelihood security. While much attention is placed on atoll communities, where risks are often significant and all land is low-lying, no islands are isolated from the invariably negative impacts of climate change.

3.4 Traditional Food Security

In Pacific Island societies, as is the case in many parts of the world, food does not simply fulfil a biological function. It has a variety of social, cultural and spiritual values (Pollock 1992) and in most parts of the region certain foods have special status, including staple carbohydrates (especially yams (*dioscorea* spp.) and taro (*colocasia esculenta*)) and forms of protein, especially specific species of fish and pigs. These high-status foods vary, partly depending on the ecological conditions. Pacific Island agricultural systems reflect climate regimes, with taro typical on the wet or eastern sides of islands (facing moisture-laden trade winds) and yams often found on the leeward or dry sides of islands, a classic distinction made famous by Barrau (1965). In some places, irrigation systems, sometimes referred to as 'brook fields', were developed to enhance or sustain taro production given its preference for moist conditions. Modification of the environment was, and still is, found in

Table 3.1 Clarke's (1977) principles of agricultural permanence

Principle	
1	Paleotechnic—not requiring external inputs such as energy or fertilisers
2	Not self-polluting. Limited toxic outputs within assimilative capacity of environment
3	Strongly positive net energy yields. Much higher outputs than inputs, not counting solar energy
4	Contained within human rather than geological timescales (no fossil fuels)
5	Equitable distribution of outputs among members of population
6	Resources seen as productive capital to be preserved
7	Polycultural crop diversity

many places. One example is the use of large mounds in parts of the PNG Highlands to support sweet potato cultivation, which enabled cultivation at high altitudes and enabled some resistance to frosts and drought conditions experienced during El Niño events (Waddell 1972; Allen 1989; Allen et al. 1989). Less elaborate techniques were widespread.

Many aspects of food security appear to have existed in many different parts of the region in pre-contact times, some for millennia, although sometimes in superficially different guises. Bill Clarke (1977) used the term structures of permanence to describe the approaches involved in agroecosystems in the PNG Highlands (see Table 3.1). Such systems would now be called sustainable (and the prototypes of permaculture), and their efficacy is illustrated in the large number of islands that, despite their representation as sites of human vulnerability, have continued to support their populations over several millennia. Moreover, despite most Pacific Islands having high levels of exposure to tropical cyclones and drought events, particularly associated with phases of El Niño Southern Oscillation (ENSO), among other extreme climatic and geological events, almost all have remained populated.

3.5 Surplus Production

A feature of traditional food systems in PICs was the production of agricultural surpluses. Indeed, according to Fisk (1964) traditional Melanesian societies lived in conditions of subsistence affluence in which needs were met with limited labour input, surpluses enabled ceremonial feasting and other activities, and supplies for times of shortage, while people had ample leisure time. Subsequently, Sahlins (1972) suggested that such 'affluence' was made possible only by having limited material aspirations, a kind of 'Zen affluence'. Typically, pre-contact Pacific communities were characterised by subsistence production, in which the producing and consuming units were the same, with some surplus set aside for times of scarcity (seasonal or through extreme events) or used for various forms of exchange (Campbell 2006).

Many Pacific Island food systems are seasonal with periods when harvests are limited. While yams can be kept for prolonged periods if stored in dry conditions many other traditional staples (for example, taro and breadfruit) require some preservation in order to be kept for future use (Pollock 1992). Probably, the most widespread measure was fermentation, where crops were ensiled in leaf-lined pits and covered with earth or sand to be dug up when required. Other methods included producing flour, simply leaving crops in the ground (e.g. alocasia and dioscorea) and drying (taro and breadfruit). Food preservation was not as common in the more fertile large islands of the Western Pacific, especially in Melanesia, with greater biodiversity than the small islands of Micronesia and Melanesia, except where islands were exposed to climatic extremes that affected food crops (Campbell 2006).

3.6 Agricultural Diversity

Biodiversity remains a key element of ecosystem stability, and traditional Pacific Island agricultural systems usually maintained a diversity of crops (Clarke 1977; Thaman et al. 2002). This polycultural approach reduced the likelihood of total crop losses during extreme events. While most places had dominant staples, many other subsidiary crops were also grown with different levels of resistance to strong winds, heavy rains and waterlogging, salinization and drought conditions. Thus, yams survive quite well in dry conditions but are averse to the wet; they are also relatively resistant to wind damage. If, however, heavy rains follow tropical cyclones, the roots may be damaged or destroyed in the water-logged soils. In comparison, taro struggle in dry conditions and while relatively wind resistant compared to, say, cassava (*manihot esculenta*), damage caused by the stems blowing about in the wind may cause the roots to rot. Planting both tree and root crops was a useful strategy.

Diversity was not simply limited to the variety of crops grown but also to the locations of agricultural sites. While anathema to some agricultural economists for seeming inefficiencies, fragmentation enabled some gardens (based on elevation, different distances from storm centres and aspect or orientation) to experience less harm than others. Other crops that were traditionally cultivated include alocasia and cyrtosperma taro (generally less preferred because of taste and status depending on environmental context) which were also less likely to incur damage compared to the colocasia taro. Bananas, on the other hand, are highly vulnerable to strong winds and can be easily damaged. On atolls, the range of food cultivars was more limited than on high islands but diversity was still sought with food systems based on alocasia (grown in artificial soils created in baskets lowered into the freshwater lens), pandanus, breadfruit and coconuts.

Most societies had famine foods of some kind, those food plants (and animals) that were not usually consumed unless normally harvested crops failed. They included plants that grew wild (especially in natural forests) and others, while not planted, were husbanded by their potential consumers. Some common examples of famine foods in the Pacific included sago (*metroxylon* spp.) and alocasia both of which require special treatment before becoming edible. Both these two famine foods are staples in some areas with limited resource bases or environmental conditions such as on atolls, where alocasia is grown and some swampy lowland delta areas in Papua New Guinea, where sago is the staple. In smaller islands, like Bougainville, sago was both a famine crop and a support for social events (Connell and Hamnett 1978). Other common famine foods include wild yams, arrowroot and a wide range of nuts such as the Tahitian chestnut, and various ferns, fungi and leaves (Clarke and Thaman 1993).

3.7 Intra- and Intercommunity Cooperation

Many PIC societies monitored food production and consumption and had controls over premature harvesting and 'political' systems characterised by leadership that at times of food stress was able to ensure that consumption of food and water supplies was controlled. Several early reports from the region indicate that food and water were rationed during times of hardship (e.g. Wilkes 1845; United Kingdom Parliament 1887). Indeed, while there were elements of Sahlins' Zen affluence, traditional communities suffered hardships at times of food stress, and population controls were normal (Klee 1980). A key to traditional food security was therefore cooperation within and between communities.

A critical element for cooperation was the maintenance (production, storage and preservation) of surpluses, beyond their offsetting local shortages, enabling the establishment of emergency stocks and thus sustaining political, social and kinship linkages with a range of exchange partners. Surplus production, then, provided a basis for intercommunity (often interisland, or in the case of 'mainland' Papua New Guinea, long-distance overland) exchange networks. Such networks had a social, cultural and political basis, alongside a more prosaic element with basic items exchanged away from the spotlight of the ceremonial presentations among chiefs and other leaders. Surpluses enabled the ceremonial feasting associated with such exchanges and also underpinned the exchange of different food and other products exploiting ecological differences among communities.

One example of such networks is the *solevu* which operated at several scales in eastern Fiji. Thompson (1940: 73) describes such a system in Kabara, an island in the Lau Group:

> Large competitive ceremonial exchanges (*solevu*) are made according to a definite ceremonial pattern based on the *sevusevu* rites which were formerly used to make offerings to the ancestor gods but are now used to present first fruits to the chief. On Kabara a *solevu* with deferred payment is occasionally held between the rival villages, Tokalau and Qaliqali, and between Udu and Lomati. Each village tries to outdo the other in quantity of food presented. Several months or years may elapse between the initial payment and the return payment.

The *solevu* also extended across Eastern Fiji and linked together islands with differing specialisations as described by Thaman (1990: 70):

> Whereas Lakeba, Moce and Cicia, together with Moala and Matuku, are volcanic islands which produce a surplus of taro and other root crops. Kabara, Vulaga, and Ogea are limestone islands with poor agricultural potential, but extensive stands of *vesi (Intsia bijuga),* and other timbers needed for woodcarving, house building, and boatbuilding. Skilled artisans on these islands produce mats (*ibe*), bark cloth (*masi*), kava bowls *(tanoa)* and other wooden vessels, boats, and house timbers which are traded or exchanged for staple root crops, pigs, or other foodstuffs.

Sahlins (1962: 369) shows the link between this exchange system and food security:

> Not only are ecological potentials in each region thus maximised, boosting the productivity of the entire area, but near monopolistic production of certain craft goods sustains the trade potential of each particular island, and this can become critical if food supplies suddenly run low (e.g. after a hurricane).

These interdependent networks of kin, political allies and economic partners could be called upon by participants finding themselves in times of hardship facing food stress following extreme events. Exchange networks, albeit with different social and political contexts, were found across the Pacific region, not only among islands, such as the famous *kula* ring in the Trobriand Islands, PNG (Malinowski 1922) and the *suqe* or graded society of Vanuatu (Campbell 1990). Extensive networks between the sea and the PNG Highlands enabled exchange of marine produce with goods from far inland (Hughes 1977), while, during major crop failure in the Highlands, people obtained food from and moved downslope to join, communities that had not been as adversely affected (Waddell 1975). Some degree of mobility was invaluable.

Food security in pre-contact PICs was sustained then through resilient agroecosystems (crop diversity and famine foods, for example), surplus production and the existence of interdependent networks based on kinship, political and social networks. This enabled communities to be sustained in 'normal' times and during periods of stress such as following the occurrence of extreme environmental events. These patterns were to change with the intrusion of European explorers, traders, missionaries and colonialists into Oceania.

3.8 Colonialism and Independence: The Decline of Food Security

Many of the measures that contributed to food security in pre-contact times are no longer found in many parts of the region and others are much less important. Two main reasons account for this deterioration. First, a major influence has been the emergence of the cash economy during the early colonial era and its subsequent consolidation. A key element of this change has been the introduction and then expansion of commercial tree crops. In much of the Pacific, and especially in many smaller islands, this took the form of expansion of coconut cultivation for the production of copra. The coconut is one of the few crops that can be harvested, dried (in the form of copra) and then stored. A significant demographic feature of many Pacific Islands was depopulation that began with introduced diseases (and the so-called 'labour trade') and continued well into the twentieth century. Population densities in many parts of the region declined, and land formerly used for food production was planted with coconuts without threatening food security. A 'dual economy' emerged with communities producing subsistence food alongside commercial copra production. With the rebound in populations, from roughly around the mid-twentieth century, with many PICs now having high rates of increase, shortages of land for subsistence food production emerged, especially on coasts.

One response to this has been to reduce fallows in the subsistence food production sector, thereby reducing soil fertility and long-term yields. The second response was to replace traditional crops such as yam and taro with the introduced, non-traditional cultivar, cassava, which, because of its lower soil and labour requirements, has become the predominant staple in many parts of the region. Rather than being polycultural, agroecosystems have emerged with two 'monocultures' (one subsistence and the other commercial) existing side by side. While populations continue to increase, food yields usually decline. At the same time, commodity prices for tree crops such as copra are notoriously unreliable and often cash returns are also very inadequate.

Furthermore, many traditional exchange systems no longer exist. In most of the archipelagic nations in the Pacific, 'traditional' forms of transport are rarely used while 'modern' interisland shipping has deteriorated in frequency and regularity. Exchange systems have also deteriorated. Thus, craft goods that once underpinned the *solevu* in Fiji are now sold cheaply to intermediaries who serve the tourism industry. In northern Vanuatu, the *suqe* has also declined, partly because the Melanesian Mission which dominated proselytization in this region after 'tolerating' the institution, decided to call for its abandonment in the 1920s as it was distracting people from participation in church activities. Valuable items such as shell money and mats lost their status as the shilling and the franc became the dominant currencies (Campbell 1990). Most significantly, with the penetration of capitalism throughout the region, store goods such as rice, biscuits and canned fish and meat replaced preserved foods as a means of dealing with seasonal shortages and providing diversity. While population numbers remained relatively low, earnings from copra and other cash crops supported this change. However, when food production was hindered by extreme events such as cyclones and droughts, cash crops could also be affected, and the income be unavailable for food purchases. Without storage or cash, food security could be threatened.

Second, food security was affected through changed responses to hazards, and the weakening and loss of traditional forms of disaster resilience. Most PICs experience some environmental extremes including droughts, cyclones and 'king' tides, the effects of all which are exacerbated by climate change and sea level rise, which may reduce agricultural productivity through such processes as soil moisture stress, wind damage, waterlogging and salinization. However, the role of famine foods has declined throughout the PICs, partly because of the provision of food relief from national and international agencies. Just as capitalism undermined the need for surpluses to sustain kinship networks and intercommunity exchange, provision of food relief reduced the need for communities to store and preserve food, maintain their planting and retain the knowledge of how to prepare famine foods. Food relief further reduced the need for intercommunity responses that were already under threat. Hazards and the supply of alien relief foods thus entrenched the processes through which food security was degraded.

This process is outlined in Fig. 3.2, which shows long-term changes in food security, punctuated by disaster events and the provision of relief. Extreme environmental events did not necessarily result in disasters, since societies had coping mechanisms (Campbell 2006; Gaillard 2007, Gaillard and Mercer 2013; McNamara and Prasad 2014; Mercer et al. 2009), but loss of food security 'created' disasters where local communities could not cope without external assistance. Disasters and changing responses to them have played a significant role in the reduction of food security in Pacific Islands. Many of the long-term changes (loss of intercommunity exchange, loss of crop diversity and famine foods, and replacement of resilient crops) were offset following disasters by the provision of food relief, simply enabling such changes to continue. The outcome was that many Pacific communities became more dependent on food imports, even during 'normal' times. This provides a challenge for how food security in PICs might be restored both under normal conditions and when disasters occur. Moreover, projections of climate change in the region suggest that climate extremes may become more severe and/or more frequent placing even more pressure on a system already under stress.

Three recent Category Five tropical cyclones indicate that cyclone intensity is presently increasing. Cyclone Pam in Vanuatu (2015), Cyclone Winston in Fiji (2016) and Typhoon Yutu (2018) in the Northern Mariana Islands were the most severe events since accurate recordings of cyclones have been possible. Pam and Winston caused great devastation amounting to 61 and 32% of the GDP of the two countries, respectively. Losses in the subsistence sectors of the two countries were particularly severe. All three events were followed by major food relief programmes and activities to enable the planting of fast maturing crops, much through international assistance (FAO 2016; Government of Vanuatu 2015; Radio New Zealand 2018). In 2015–2016, a severe drought in the Marshall Islands caused damage to subsistence agriculture that led to a 4–6-month food relief programme (Republic of the Marshall Islands 2017), while freshwater supplies had to be imported to Tuvalu and the Northern Cook Islands. A combination of declining food security and increasing disaster magnitude is likely to provide serious challenges to the capacity of communities to sustain independent access to food in coming years and decades.

3.9 Food Security in Contemporary Pacific Island Societies

As the preceding discussion indicates, with some exceptions, food systems have sustained most island communities over millennia. However, levels of food security

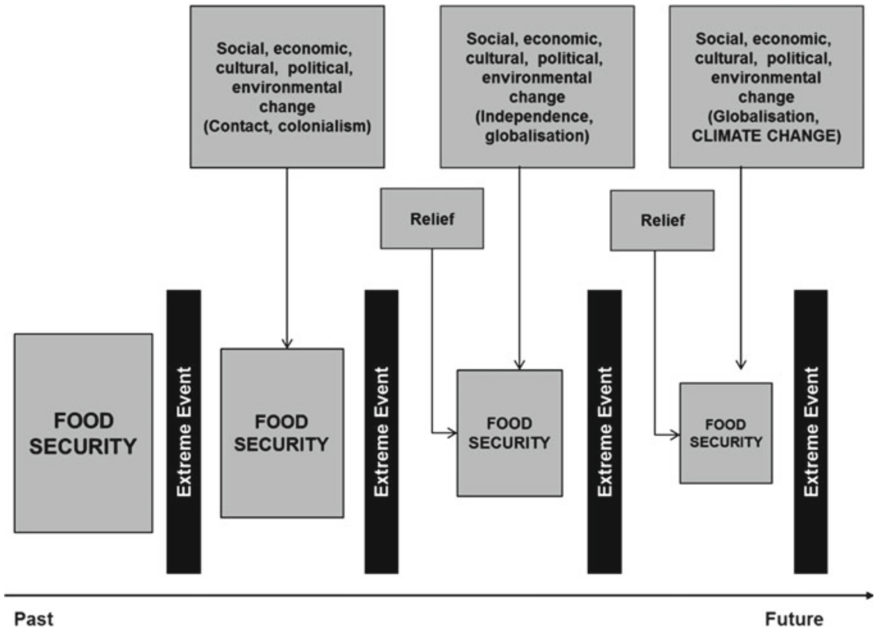

Fig. 3.2 Changing food security: the links between food security, long-term social and environmental change and environmental extremes. Traditional food systems provided sufficient security for most communities to survive the effects of extreme events. However, changes initially wrought by 'contact' and colonialism reduced levels of food security by changing agricultural and other social practices. As a result extreme events began to give rise to disasters, the losses reflecting the levels of food security. Where communities were perceived to be badly affected, food relief was supplied further eroding aspects of food security so that ensuing extreme events caused even greater levels of food stress. The figure shows changing long-term influences from contact through to the present and then into the future where climate change may be expected to further diminish levels of food security

have often declined since early colonisation and have continued to do so. Urban communities are particularly dependent upon imported foods and even in rural areas food imports have become increasingly important.

Rural communities differ in many ways, from outer islands in archipelagic nations, isolated by infrequent and irregular shipping, or expensive airfares, to inland rural communities, such as those in the PNG Highlands and also in Viti Levu (Fiji) and Malaita (Solomon Islands), which are not connected to the national capital by road and experience some of the same features of isolation as the outer islands. These remote communities face problems of food security as outlined above, with land being divided between subsistence and cash crop production, but smaller, outer islands face the greatest challenges. Upland villages have been able to retain more viable subsistence systems, since land has come under less pressure. More complex changes have occurred in villages closer to cities and effective transport infrastructure, enabling market production. Island communities, such as those on Taveuni and Kadavu in

Fiji, with relatively regular shipping services to the capital, Suva, can trade regularly, while also retaining subsistence systems (Sofer 2018). Food security in these communities is less compromised, with diversity being maintained, whereas villages close to urban centres have found it more difficult to maintain diversity, where there is an acute 'coastal squeeze' as land has value to many other agencies, but have been able to benefit from non-farm income and easy market access.

While urbanisation in the Pacific is limited compared with other parts of the globe, and Melanesian countries with large populations have low percentages of urban populations, many Polynesian and Micronesian countries have much higher rates of urbanisation. But, as Bedford and Hugo (2012) observed, urban growth will be very significant in Melanesia over the next half-century. In terms of food security, urban areas have, for a long time, often been identified as areas with the greatest levels of dependency on imported foods (McGee 1975). While urban food gardening exists in many towns and cities (Thaman 1995), it is unable to supply more than a small fraction of local needs, especially as urban areas spill over on to good agricultural land, but market gardening has grown at a greater distance, in such productive areas as the Sigatoka Valley (Fiji) and on much of Tongatapu (Tonga). However, high prices have often made access to such foods difficult for relatively poor urban residents, whereas salaried urban residents, with less time and more capital, are able to purchase a range of local and imported foods. While food imports reach all parts of PICs, the majority are consumed by urban dwellers. As urban populations grow, the demand for locally grown foods is likely to be more difficult to satisfy and the need for increased food imports is likely to grow.

While many traditional exchange networks have declined in importance and in several cases have collapsed, new contemporary networks, based on kinship (as were traditional exchanges), have emerged with urbanisation within PICs and the establishment of large Pacific Island communities in the Pacific rim countries of Australia, New Zealand and the USA as well as some central locations within the region (e.g. Fiji and Guam). More than any other part of the world, the Pacific region is dependent on remittances, some of which are foods and some of which enable food purchases (Connell and Brown 2005; Bedford and Hugo 2012). Migration and remittances may also be seen as important elements of climate change adaptation enabling the remaining communities to have higher standards of living that would otherwise be the case, reducing the numbers dependent on local resources and providing money and goods for those who stay (Barnett and Webber 2010; Campbell and Bedford 2013; Campbell 2014). That has been particularly useful in response to crisis events, with remittances peaking after hazards and, as in Samoa and Fiji, reaching affected households more rapidly than other forms of assistance and enabling them to recover more quickly (Le De et al. 2015; FAO 2016). Inevitably such processes do contribute to food dependency among those who remain.

Home remains a critical construct for most PIC migrants and it is important to sustain their ties to it. This is embodied in the notions of 'roots and routes' (Jolly 2001) and 'the tree and the canoe' (Bonnemaison 1985). The very existence of one's roots (the trees) enables migration (along routes in canoes) with the knowledge that there is a place one may return to. Those who do not migrate have the responsibility to nurture the land and keep the link between the people and the land alive. The links between migrants and the stayers are often actively maintained and are not simply one way, but regularly sustained through the transfer of food of various kinds between movers and stayers (Petrou and Connell 2017). Foods, where they are able to comply with biosecurity requirements in destination countries, and valued craft goods also move internationally. The movement of remittances in various directions and forms represents a form of interdependent food security rather than one of greater dependency. Migrants reduce the pressures on local food supplies.

Forced community relocation where entire communities are resettled also has serious implications for food security (Gharbaoui and Blocher 2016). Some communities in the Pacific region will have no option but to move from their traditional homelands as a result of climate change impacts upon land, livelihood and habitat security (Campbell 2014). However, a major problem is that the great majority of land in the Pacific region is held in customary forms of ownership that make exchange and purchase of land very difficult. Thus, attempts to obtain land elsewhere by Carteret Islanders, whose atoll is unable to support food security and faces environmental pressures, have comprehensively failed. So too have attempts to acquire land by Manam Islanders, fleeing the volcanic eruption of their island, much like many earlier attempts in Melanesia and elsewhere (Connell 2012; Connell and Lutkehaus 2017). Food insecurity, over and above the issues already outlined, is likely to be a pressing issue for relocated communities, and resettlement is a catalyst for food insecurity.

3.10 Options for Food Security in a Changing World

What are the future options for PICs? By mid-century, the effects of climate change are likely to be more evident and the projected Pacific population will be almost double that of the present (SPC 2016). The numbers of urban dwellers are expected to increase significantly. Several questions remain to be answered. First, how will rural communities fare in the decades ahead? If they continue to contribute large numbers to urban areas, they may avoid increased unmanageable population pressure on food resources. However, the expansion of commercial agriculture, especially for commodity production, has proceeded at the expense of food production, and depleted food systems are less resilient than in the past. At the same time, the returns to commercial agriculture are often poor. Ironically that might boost subsistence production, but it is more likely to lead to outmigration. It might also lead to some unproductive coconut groves being returned to subsistence production although, while copra prices are unreliable and copra has become increasingly unattractive, coconut trees have a range of uses that discourages their replacement.

A strong link exists among extreme events, food security and disaster occurrence. If climate change increases, the exposure of PICs to increases in the frequency and/or magnitude of extreme events (not just cyclones and droughts but rainstorms, king tides during higher sea levels, and the incidence of more or new agricultural pests or diseases), many Pacific Island communities would not be resilient, where resilience is now declining both in rural and urban areas. A consequent concern is how food security might be linked to steadily growing urban populations, detached from the land. Much depends on reviving transport infrastructure to enable local and regional marketing, and that challenges their present decline and the long-term lack of economies of scale. Few PICs can even contemplate a purely national response to food security, given the present substantial proportion of consumed food that is imported, especially in Micronesia and Polynesia, the decline of urban gardening, and the prestige, status and cost of imports. Disincentives to food imports are also implausible in the face of WTO trade structures. What is crucial is support for urban markets to increase opportunities for rural food production, both for subsistence and for cash, by developing transport infrastructure, and perhaps subsidising transport costs.

A further issue that needs to be approached is the role of migration, remittances and the concept of food interdependency (rather than dependency). Climate change is likely to induce more migration over coming decades, both contributing to and emanating from the reduced capacity of PICs to provide the capacity to support their populations in terms of both subsistence and commercial livelihoods, or even find the land resources for them. While there has been concern that migration, particularly forced community relocation, is an indicator of in situ adaptation failure, a less apocalyptic view of climate change-induced migration is emerging (Bettini 2013; Hartmann 2010; Kelman 2014; Nicholson 2014), where it proves beneficial when options for in situ adaptation are limited (Barnett and Webber 2010; Campbell and Bedford 2013; Campbell 2014). Climate change-induced migration has the capacity to both reduce population pressure on a degrading resource base, leaving greater subsistence opportunities (and possibilities for food security) among those who remain, and improve livelihoods when migrants are able to support the home communities with remittances that may in turn help reduce food insecurity and reduce, especially on outer islands, the need to increase dependency on a generally underperforming commercial agricultural sector.

To achieve and sustain such food interdependency, several issues need to be addressed. It assumes that migrants will have access to metropolitan countries, but that seems increasingly difficult under current international migration regimes, even for climate change ‘refugees’. Bedford and Hugo (2012) somewhat optimistically suggest, for example, that migration could be facilitated by providing migrants with dual citizenship. However, although both New Zealand and Australia have provided a diverse range of short-term migration options, Australia particularly has been unwilling to offer long-term support. Nonetheless, migrants have often found a way, and it is increasingly important that they can continue to do so, to offset remittance decay and to support bidirectional trade and exchange and thus provide direct and indirect support for food security (see Fig. 3.3).

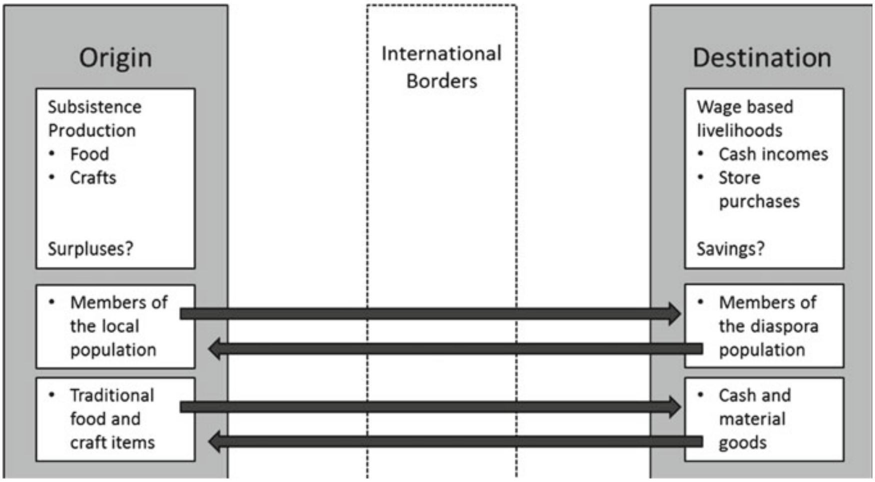

Fig. 3.3 Facilitating maintenance of transnational kinship linkages. One way of maintaining food interdependency is to sustain transnational kinship linkages which may, in a contemporary context, replace traditional intra- and intercommunity networks. One way to do this is to facilitate two way follows of goods and people between islands of origin and destination locations requiring new international arrangements for migration access including 'climate change migrants', border protection (e.g. biosecurity) and reducing the costs of international money transfers

3.11 Conclusion

Pacific Islands were once places with high levels of food security, where people may have lived in 'structures of permanence' with subsistence affluence, albeit based on moderate, unchanging material aspirations and at severe risk during droughts and cyclones particularly. Today, such conditions do not exist and both rural and urban communities in the region face high levels of food insecurity that are heightened by disasters, climate change, new structures of urbanisation and material aspirations, price regimes that favour imports at the expense of local marketed goods, and rising expectations. Projections of population growth and scenarios of climate change indicate that food stress may become worse rather than better unless measures are taken to redress the current problems. While this could be achieved through strengthening the resilience of local communities, changing the ratio of subsistence food production and cash crops, revitalising the use of famine foods and rekindling old and adopting new ways of preserving food crops, none of these appear particularly promising or, indeed, supported by local policy directions and practices. It is more likely therefore that, by building on transnational kinship networks and ensuring a flow of remittances, whether domestically or internationally, capital will be available to support local purchases and therefore local market production: enabling a new structure of interdependent food security that simultaneously offers employment possibilities. Without new policies and practices, it is likely that many PICs will become increasingly characterised by food dependency and find themselves in an invidious position as climate change impacts unfold.

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Chapter 4
Lost Roots? Fading Food Security in Micronesia

John Connell

Abstract Food security in Micronesia has worsened in the past half-century. Agriculture, fishing and local food production have all declined, even in the most remote islands, especially in peri-urban environments. Diets have incorporated more processed and imported foods, because of prestige, accessibility, cost and convenience, at financial, social, environmental and nutritional cost to countries and households. NCDs (non-communicable diseases) have grown rapidly throughout Micronesia. Household expenditure is dominated by imported foods, especially rice. Food security requires more adequate market access, but national resource bases are limited, and government intervention and policy formation are both weak and exhibit urban bias in unusually fragmented states. Households have negotiated multiple livelihoods across international boundaries with national and household incomes boosted by remittances which may become a distinctive key to achieving improved health and nutritional status.

Keywords Food · Nutrition · Micronesia · Pacific · Islands · Incomes · Livelihoods

4.1 Introduction

> When we get sick we go to see the doctor and are told we need to eat cabbages and other greens to help us control our diabetes but the problem is where do we get the money to buy the cabbage and other greens? And where can we find space to plant on Majuro? Sometimes traditional foods may be found in the stores but we do not possess the financial means to purchase them. Money, or the lack of it, is the root of all our social problems. If people had enough money they would not have to worry so much and would be able to buy all the

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> healthy and nutritious food their bodies require (Marshallese women, quoted in McMurray and Smith 2001: 152–5).

Food security has worsened in Pacific islands in the past 50 years despite numerous regional and international organisations, and national development plans, promoting policies and programmes are designed to encourage greater self-sufficiency in food production and consumption, and more adequate food security, mainly by encouraging improved local production (Thaman 1982) but with few positive outcomes. Early advocates of greater food security were concerned over a number of related issues: first, the high national cost of food imports (as a proportion of all imports), a negative balance of payments, sometimes extending to concerns over household expenditure; second, the potential for undernutrition (with the loss of local diversity, high and volatile prices of imported goods and inadequate incomes); third, a related health/epidemiological transition towards non-communicable diseases (e.g. diabetes) with the shift in diets and fourth, the social costs of some transitions (e.g. alcohol), and concerns over cultural dependency (e.g. in the shift from coconuts to Coca-Cola), as local foods are not ‘instant' and are more conducive to conviviality and attuned to traditions of sharing and reciprocity. Distinct problems are attached to food security in atolls (especially urbanised atolls), where traditional diets were always limited, and in the growing urban centres (where the poor were disadvantaged).

Inadequate food security stems from, first, a decline in the local availability and production of subsistence foods—whether from land or sea—ironic in a ‘sea of islands' where food and its sharing symbolise social relations. Second, it follows the lack of income (and infrastructure) to secure adequate alternative foods. A number of now well-known factors have posed problems for development in small island states, with a narrow resource base contributing to limited diversity of production and exports that in turn create problems for food security (Connell 2013). Such problems have been bound up in a series of food regimes that have constantly favoured export crops above domestic food production (Plahe et al. 2013). Consequently, food security has worsened in the Pacific in recent decades because of falling food production per capita, low growth in agricultural production and increased and costly dependence on food imports (SPC 2011). This chapter seeks to provide an overview of trends in the smaller Pacific islands, with particular reference to atolls in the three largest Micronesian states—the Marshall Islands (RMI), Kiribati and the Federated States of Micronesia (FSM)—where achieving economic growth has been unusually difficult, aid dependence is considerable, food security has long been a problem and nutrition assistance programmes were established as early as the 1960s (Connell 1991; Denman and Dewey 1989). The three states have a combined population of 267,000, and are primarily composed of coral atolls, although FSM has four central high islands. Reference is also made to atolls elsewhere, especially in the adjoining atoll state of Tuvalu. Both Kiribati and Tuvalu were former British colonies (as the Gilbert and Ellice Islands) and FSM and RMI were previously an American administered Trust Territory (Fig. 4.1).

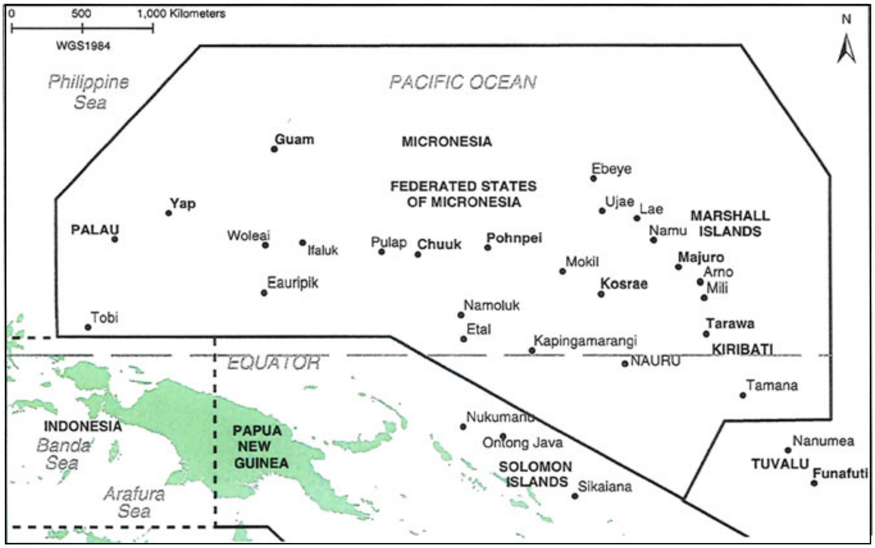

Fig. 4.1 Map of Micronesia

4.2 'Food Dependency'

What has been termed 'food dependency', 'dietary colonialism' or, for Kiribati, 'gustatory subversion' (Lewis 1988), emerged in colonial times with the diffusion of 'European' foods that symbolised a degree of welcome modernity. Imported foods, especially rice and tinned foods, became staple diets on plantations and in incipient towns, gradually diffusing into rural and remote areas, to be incorporated in local diets. Plantation workers, and later bureaucrats, were the earliest consumers of imported foods (Coyne 1984). Colonial governments had little interest in food production, as they sought to expand cash crop production. As local people cultivated cash crops, the land was gradually transferred from food crops, food gardens were displaced further from villages and less effort was expended there. In Kiribati, to pay for food imports, coconut production was expanded by cutting down pandanus and breadfruit trees, labour was shifted from taro pits to copra production, so reducing an already limited choice of local foods, while sale of coconuts that had previously been stored as 'drought foods' increased vulnerability (Lewis 1988; Feinberg 1986). Changing tastes influenced these trends, with some local species no longer regarded as appropriate nutrition. Deforestation, reduction in biodiversity, declining knowledge of plants and their utility (e.g. Thaman et al. 2010) and lack of adherence to traditional conservation practices, reduced the significance of wild foods, whether fauna or flora. Complex subsistence food production systems gradually gave way to less intensive agricultural systems, with less diversity of production and therefore of nutrition, and greater dependence on the market economy. Loss of diversity reduced productivity, cultural utility and ecological stability (Clarke and Thaman 1997) and increased hazard risk, with implications for residual food security.

Absorption into increasingly global systems resulted in diets gradually shifting to incorporate imported foods because of, first, the status, prestige and modernity often attached to them (and the ability to purchase them); second, the sweet taste and ease of consumption (especially welcomed by the young); third, convenience (especially after hazards)—for purchase, preparation, cooking and storage; fourth, variety (especially on atolls); fifth, necessity (notably in growing urban areas, where wage earners were without land and time); sixth, because imported foods were often cheaper than local foods and seventh, mass marketing and promotion, at least in the more modern era. Finally, and more controversially, people 'were said to be lazy and therefore to prefer Spam, canned tuna and canned mackerel over seafood that they must catch themselves' sometimes imputed to a 'moral decline' that followed monetisation (Rudiak-Gould 2013: 27). In much of Micronesia, a shift away from traditional foods was encouraged and inculcated by American school lunch programmes where elementary school students received rice, tinned meat and fish, noodles and other processed foods, some of which was taken home by students to share with relatives (Flinn 1988; Denman and Dewey 1989). Modern food was associated with modern education.

4.3 Agricultural Decline

Subsistence agriculture has almost disappeared from some Micronesian islands, as populations have become more urban, agricultural work offers fewer attractions (especially for youth who disdain agricultural employment) and food is increasingly purchased, alongside conversion of agricultural land to other uses, ageing farmers, inadequate prices and weak marketing infrastructure, 'parcelisation' of land into tiny plots through inheritance, price fluctuations (especially for copra), 'modern' education and higher wages in the formal sector. After trade liberalisation in the mid-1990s, many islands experienced a surge of cheap food imports, making local production more vulnerable and marginal. Subsistence and cooperation have evolved towards commercialism, individualism and new forms of consumption, with a resultant loss of community and social cohesion.

The greatest shifts in agricultural production and marketing have been, first, the result of lavish provision of food aid in several parts of Micronesia, but especially in RMI, following population resettlement after nuclear testing (Ahlgren et al. 2014) and second, the outcome of changes in the global trading system. Production of many long-term staples, notably copra, has declined; several are no longer traded since prices in remote places are too low to justify marketing (although Kiribati now subsidises copra production). Copra has gone from many Micronesian atolls, victims of the 1990s copra crisis, scarcely remaining even where there are no other local income earning opportunities (Pollock 1996; Chambers and Chambers 2001, 2018; Rudiak-Gould 2009). Inability to achieve economies of scale, production costs (including labour) and the cost of credit affected competitiveness, while larger countries were better placed. Greater integration and free trade theoretically provide incentives for local producers to become more efficient, diversify and specialise, but intervening opportunities and multiple other factors prevent this, especially on atolls (Hezel 2006; Connell 2013). Unable to compete in deregulated markets, household-based agriculturalists have simply withdrawn from commercial farming.

Local markets provide a potential source of income for villages not too distant from urban centres, and such 'subsistence incomes' are often the dominant source of income where wage employment is scarce. Distant villages have been disadvantaged by rising fuel prices so that rural people no longer market produce. A combination of static (or declining) production and high transport costs means that in many urban Pacific markets, food prices are extremely high, as in Kiribati, a situation reported on for 30 years (Thaman 1982; Connell 2013; Christensen 1995), discouraging the purchase and consumption of locally marketed food. Moreover, cooking takes time and scarce or expensive fuel; even when available, traditional Marshallese foods are regarded as too expensive and too time-consuming to cook (Culpin 2017). In the three atoll states, Kiribati, Marshall Islands and Tuvalu, urbanisation has been so extensive that virtually no land remains on the central urbanised atolls for food production, other atolls are too distant for effective and economic market participation and unlike other Pacific countries, fresh food markets are conspicuous by their almost complete absence.

Atolls with capital cities, notably Tarawa, Majuro (and also Ebeye) and Funafuti, have experienced a 'coastal squeeze', where populations have increased, high-density urbanisation has occurred and agriculture has disappeared (or, exceptionally, intensified). Land shortages, tenure constraints, preferences for wage employment, new tastes, poor marketing infrastructure and disappointing returns have all further discouraged food production. Modern education has taken youth from fields, gardens (and lagoons), hence indigenous technical knowledge has declined. Such disintensification has usually involved a reduced agricultural area (both absolutely and per capita), a shift from more demanding crops (in terms of labour) and techniques (such as irrigation and mulching), and the loss of some cultivars.

Particularly demanding pit cultivation of taro, the traditional staple of most atolls, has universally declined or disappeared, even when not threatened by hazards, as a labour-intensive activity of low status (e.g. Marshall 2004; Oles 2007b; Rudiak-Gould 2009). Even on atolls, where agricultural diversity was always minimal, labour-intensive activities were abandoned early in the twentieth century; on Arno (RMI), only one-tenth of the taro pits were planted by 1950, and abandonment was apparent on other Marshallese atolls like Namu, Lae and Mili by the 1960s (Pollock 1992; Connell 1994), and by the 1980s in the more remote atolls of Bougainville (Feinberg 1986; Pollock 1992). Even on remote atolls like Woleai (FSM), taro patches were not well maintained by the 1990s—a function of land tenure disputes, disdain for agricultural pursuits and frustrations over saltwater incursions after typhoons. Nonetheless, in most places, new crops have also been introduced because of their higher yields, ease of cultivation or preferred taste (see also Scourse and Wilkins Chap. 5, this volume). On the raised atoll of Bellona (Solomon Islands), broad patterns of land use have remained much the same for 40 years, but crop combinations changed with sweet potato and cassava (which require less labour input) becoming more dominant, with some reduction in crop (and nutritional) diversity. Greater access to cash, mainly from remittances, resulted in agriculture becoming simply a supplement to a diverse 'portfolio' of livelihood strategies (Birch-Thomsen et al. 2010).

In precolonial times, food storage was common, though never easy where root crops were staples, to ward against natural hazards (where cyclones might destroy taro pits and coconuts for many months) but this labour-intensive activity has given way to a dependence on government supplies and the abandonment of 'famine crops' such as arrowroot, gone from the Marshall Islands by the 1970s (Connell 1994). In the 1990s in Laura, on Majuro atoll (RMI), breadfruit was being allowed to fall and rot, because money was more readily available and people preferred store food that was quicker to prepare (Pollock 1996). Where income generating activities existed outside agriculture, or remittances were particularly substantial, the transition away from agriculture was rapid, as on Mokil/Mwoakilloa (FSM) (Oles 2007a, b) and Ujae (RMI) (Rudiak-Gould 2009). On atolls such as those of the Tuamotus (French Polynesia) people prefer to 'eat from the store' and have no wish to 'return to the past', although nutritional status has declined (Chazine 2005). When a UN Integrated Atoll Development Project in Woleai (FSM) in the early 1990s demonstrated more intensive agricultural techniques that would increase root crop production, the local response was: 'We know all that but we have money now so can go to the store'.

Where migration has been considerable subsistence agriculture generally plays a reduced role, imported foods have become more important and agricultural land has gone out of use, Agriculture is widely typified and derided as an activity of low status and prestige, especially for men. In the Cook Islands, men who work on the land (or in other forms of manual labour) are described as *repo taro* ('dirty taro') a derogatory term that also refers to 'nothing men', without land or capital, who are typically also denigrated as coming from outer islands and atolls (Alexeyeff 2008). On Mokil those who eat fish and taro, and have no tinned meat, are either vilified or pitied (Oles 2007b). Atoll places and people are the antithesis of modernity. Over half a century ago in Samoa, declining interest in agriculture and the presence of uncultivated land was the outcome of the 'low social status accorded to skill and diligence in agriculture' (Ward 1959: 126). Such attitudes have hardened and farmers are universally ageing.

Yet significant agricultural decline is not universal. In relatively remote islands, such as Anuta and Tikopia (Solomon Islands), Tobi (Palau) and Pulap (FSM), agricultural diversity has been retained (partly out of necessity as transport links with distant capital cities have worsened), which has incidentally strengthened food security and enabled the islands to be more resilient to hazards (Flinn 1988; Mertz et al. 2010; Furusawa and Ohtsuka 2009). Islanders have also revitalised subsistence agricultural systems when cash incomes have declined for some reason, as on Ontong Java atoll (Solomon Islands) (Bayliss-Smith et al. 2010), if migration is not a viable option. Where externally oriented economies have collapsed dramatically, as on Nauru, with the effective demise of phosphate mining at the end of the twentieth century, agricultural systems have been slowly revitalised even in hitherto unpropitious circumstances.

By contrast on such central atolls as Tarawa, Ebeye and Majuro, many young people have neither seen nor experienced the traditional agricultural economy, nor have they consumed much traditional food as outer islands have no marketable surpluses. That poses direct problems for weaning (Christensen 1995), emphasises how food transitions have been partly driven by youth (Flinn 1988) and points to problems for shifting dietary preferences towards local products. Until quite recently, Pacific islands economies were characterised both by limited monetisation and by the existence of an agricultural and fishing system, which offered both a 'subsistence safety-net' and an 'exit option' from inadequate cash crop prices (Rodman 1987). As subsistence economies have weakened, market orientation strengthened, and land degradation occurred, safety nets have frayed, making sustainability, food security and withdrawal from an urban and global economy more difficult to achieve.

4.4 Fishing

Fishing is at least as central to the livelihoods of small islands as agriculture. Trends in Pacific island fisheries have been similar to and paralleled those in agriculture, usually much less visibly, in itself constituting a problem. In Micronesia, not untypically, the catch value of inshore fisheries has declined relative to inflation and the cost of imported goods (Rhodes et al. 2011; Houk et al. 2012). As some species have been depleted and catches fallen, local inshore fisheries have gone further offshore but been out-competed by larger foreign-owned longliners. Technological changes and market expansion have influenced patterns of exploitation, distribution and consumption, and greater ease of access and 'modern' education have tended to result in attenuation of local knowledge of fishing techniques and fish behaviour, as in et al. and Kapingamarangi (FSM) (Nason 1975; Lieber 1994). Even in remote atolls, superior access to modern technology (from steel hooks to outboard motors and freezers) has resulted in greater efficiency, greater individualism and competitive activity, rather than communal activity, with fishers becoming more rapacious, individualistic and competitive (Oles 2007b), as modern fishing gear is easily handled by individuals, more accessible and affordable. Blasting has killed off significant proportions of reefs in some areas, and children have become adept at breaking coral reefs with iron bars. Management practices, and their absence, vary considerably.

Pressures on inshore fisheries and marine environments are greatest around urban areas, especially where the poor can take advantage of this resource (in contrast to more easily guarded land resources). This has created conflicts over access to fishing grounds, reduction in species availability and less productive fishing around some polluted urban areas, notably Majuro, with a consequent rise in prices and diminished accessibility of fresh fish. It has been predicted for the Pacific Islands that from 2010 to 2035:

> The amount of fishery products originating from coastal fisheries that is accessible to urban residents will decline sharply due to overexploitation and habitat destruction. A growing proportion of the population will not be able to catch sufficient fish to provide for household consumption, and purchased fish will become relatively expensive. Food security issues will grow tremendously in importance (Gillett and Cartwright 2010: 7).

Even well-managed coastal fisheries will only be able to meet demand in a few island states by 2030, although one of these is RMI, and alternative subsistence and income sources are urgently required (Bell et al. 2009; Kronen et al. 2010). Effective management is needed but a lack of political will, weak enforcement of fisheries regulations and few income generating alternatives have resulted in noncompliance and degraded fisheries (Peterson and Stead 2011). Larger fish are more likely to be in decline since they are targeted by local and international fishers, mature more slowly and often form aggregations, which increases their vulnerability. Local fish consumption is the main driver of decline of inshore fisheries, especially where fish are a significant and (for some people) a unique marketable commodity. Fish marketing has, however, been problematic in many places, and especially outer islands, because of the absence of freezers and other infrastructure (notably regular transport), and the lack of knowledge and capital for commercial orientation.

Social change and diverse market pressures have meant that various conservation practices have disappeared, even in relatively remote areas where populations are not growing quickly. On Ujae, the traditional system of environmental stewardship had collapsed (Rudiak-Gould 2009). Management practices have come under increased pressure with sustained entry into the cash economy, increased capacity for exploitation through improved gear technology (e.g. nylon nets, spear guns, snorkelling masks, waterproof torches), weakened leadership and reduced respect for custom (Johannes 2002; Ruddle 1998; Veiteyaki 1997). Younger people place less value on management and view the sea through a commercial rather than 'traditional' lens (Veiteyaki 1997; DeMers and Kahui 2012).

Traditional fisheries systems have generally shifted towards more open-access commons (Aswani 2002; Christensen 2011), resulting in widespread efforts to introduce marine protected areas (MPAs) to reverse resource depletion, despite considerable reluctance, where fishing livelihoods are perceived to be at stake. Where population density is greater and population growth faster, establishment and compliance have been weak, yet relatively remote islands where populations have not grown have retained a greater suite of traditional management practices and have more effective MPAs (Aswani 2002; Aswani and Vaccaro 2008).

Poverty, few alternative opportunities and uneven development, constantly trump management and conservation whether of woodlands or coastal waters, so that sustainable management is rare, epitomising the 'tragedy of the commons' with inadequate regulation and self-interest overcoming cooperation (Wilkinson and Salvat 2012). Economic and environmental issues are routinely intertwined. In the Lau islands (Fiji), as people gained alternative incomes, they became less dependent on fishing and exerted less pressure on the marine environment, while isolation from markets prevented fishing down the food chain, as occurred closer to markets (Turner et al. 2007). Where poor people depend on marine resources for food and income, especially in peri-urban areas of Micronesia where social controls are weakest, management is least effective. It is here above all that the ‘subsistence safety net’ has largely disappeared, and the nexus between poverty, inadequate nutrition and resource degradation become most evident.

4.5 Coral Island Linkages

Achieving sustainable livelihoods on small islands and especially atolls has often been difficult. In precolonial times, islands achieved sustainable development partly through extended geographical ties, typified by dispersed clans and linkages across atolls and between clusters of islands, marked by elaborate exchange systems and complex regional and local reciprocal socio–economic–political linkages, to secure social relations and claim and use land elsewhere (Alkire 1978; Petersen 2009). Population growth was also regulated, sometimes by such means as abortion, infanticide and sponsoring one-way voyages. Islands were rarely isolated for long and even the tiny island of Tikopia (Solomon Islands) was part of a ‘world system’ for most of its 3000-year human history (Kirch 1986). Survival and adequate nutrition necessitated external ties. Small islands could not afford to be insular.

Extreme population pressure on resources was evident on many islands by the nineteenth century. In the Tokelau atolls, migration was well established in life and thought; ‘some of nearly every group of siblings must *tahe* (“emigrate”) simply because the local resources are seen as insufficient’ (Hooper and Huntsman 1973: 403–4). A century later, as in Solomon Islands atolls, migration had become ‘a household strategy, by which migrants and their families (including those staying behind) diversify sources of incomes in order to minimise risks, such as loss of income and crop failures’ (Birk and Rasmussen 2014). That has intensified as migration has been prolonged, expectations have risen and aspirations increased, and a culture of migration been established where migration was anticipated and normative (Donner 2002; Connell 2008, 2015). Changing aspirations, the increased necessity and desire to earn cash, a preference for bureaucratic employment, a taste for ‘respectability’ and distaste for agricultural work have given migration a primarily economic rationale: a movement in search of wage employment, rare in most rural areas, and the security of wages rather than intermittent crop sales. Migration became characterised by movement away from remote places to more accessible coastal locations, particularly urban areas and capital (usually primate) cities at home or abroad. Small islands became increasingly dependent on remittances.

On some small islands, population pressure on resources became such that some migration was essential, sometimes involving resettlement in distant islands, as in i-Kiribati migration first to the Phoenix Islands in the 1930s, and then to the Solomon Islands. Hazards also saw the resettlement of some outer island populations to the centre. Where feasible that also meant the colonisation of nearby larger islands as on Nupani (Reef Islands, Solomon Islands), where around the early 1960s islanders who were ‘never self-sufficient’ began to use land on much larger Ndende island, some 40 kilometres away, because of intense pressure on land, to the extent that 'every square foot of ground suitable for cultivation has long been planted' (Davenport 1969: 173, 174). By the 1980s, the southern atolls of Palau were almost abandoned, and the same pattern of growing central populations and absolutely declining populations in remote islands was emerging in other archipelagic states, including the three Micronesian states.

The outcome of migration from small islands was urbanisation, deliberately encouraged by the post-war American administration (Connell 1991). More than three quarters of the Marshallese population, half that of Kiribati and Tuvalu and a third that of FSM now live in urban centres. Modern employment opportunities and services are concentrated in urban centres, somewhat inevitable in small, fragmented states where human resources and capital are limited. As physical infrastructure decays on outer islands, youths emigrate, populations fall and age, services are inadequately provided, so incentives to remain decline, and a downward spiral is enhanced. Even on relatively large atolls, migration of younger men placed 'an exceptionally heavy burden on the able-bodied males who fish and collect both subsistence crops as well as coconuts for copra so that they and others expressed the opinion that there were not enough to make any substantial effort at developing the island's agricultural potential' (Kiste 1974: 384). Dependency ratios increased and more was expected of those who stayed, hence they too sought to migrate. Ironically, the contemporary migration patterns that in many places began in the 1960s, and alleviated stresses arising from ecological problems resulting from population pressure, became situations where the loss of labour was so great that subsistence activities were directly threatened.

As migration became international from the 1970s, remittances became a significant part of national income so that, four mainly atoll states (Kiribati, Tokelau, Cook Islands and Tuvalu), were conceptualised as MIRAB states, where MIgration, Remittances, Aid and the resultant largely urban Bureaucracy were central to the socio–economic–political system (Bertram and Watters 1985). Not only did that indicate the weakness of local productive economies, but a substantial part of remittances was spent on imported foods, especially in the earliest phase of migration (Lewis 1988; Connell and Brown 2005). Remittances from migrants constitute a significant and usually the primary source of income, for these countries and for outlying islands such as Mauke (Cook Islands) and Nanumea (Tuvalu), becoming even more crucial after the virtual collapse of the copra trade in the 1990s (Connell 2013). On such islands having large families in the hope that one or more children might eventually provide remittances was a conscious economic survival strategy.

A Pacific neologism, become a common phrase, is 'outer islands'. Such islands are perceived as different, sometimes culturally, like the outer islands of FSM, but ubiquitously because they lack the development options, service provision and modernity of centres. In outer islands, especially 'incorporation in a wider polity and the *escape* this offers through outmigration, counters the limits of small size and narrow resources' (Ward 1982: 182; my italics). Islanders increasingly recognised the need to have an established community on a central high island on which to depend (Marshall 2004; Pam and Henry 2012). Any private sector has disappeared from most outer islands, almost before it was established, and public services have suffered because of the unwillingness of providers to live in remote areas, and the breakdown of transport infrastructure. The rise of container shipping and bulk carriers, and the decline of the copra trade, has resulted in ships simply bypassing many islands, a process well in place by the 1970s, and air services have likewise bypassed small islands, further disadvantaging them.

4.6 Nutrition and Health

The outcome of shifts in agriculture and fishing, migration (internal and international), urbanisation and continued absorption into the global economy, is that food security is threatened by changing production practices, land and water degradation and land losses with food production growing slower than the rate of population increase. Changing nutrition is partly associated with declining food production, and reduced diversity, mainly derived from changing tastes, low incomes, the inability to purchase adequate diets (at high market prices), a growing dependence on store foods and the poor quality of cheap imported processed foods and drinks. Dominant consumption of local foods is seen to equate with poverty. Imported foods range from corned beef, turkey tails and meat flaps to rice, sugar, instant noodles, biscuits and soft drinks (e.g. Cassels 2006; Oles 2007b; Gewertz and Errington 2010; Rudiak-Gould 2009; Thow et al. 2010; Seiden et al. 2012). Rice and flour have become food staples even in quite remote communities, sometimes eaten without accompaniments. By the 1970s, rice was almost ubiquitous, central enough in diets to be a staple rather than merely a snack, and in Chuukese atolls at least, being categorised linguistically with traditional root crop staples (Flinn 1988). Noodles (ramen) have rapidly taken over as the ubiquitous, quintessential fast new 'modernist staple' (Errington et al. 2013: 92). Tinned fish is a common import in many island contexts, with imported fish, meat and chicken preferred to local versions (e.g. Dixon and Jamieson 2005). In Woleai, where more than 200 species of edible fish inhabit the lagoon, the best-selling item in most stores was tinned fish. Fresh fruit is imported but can be damaged and rot during transport and prices are high. Processed food is also sent from urban centres to outer islands, with one employee of a Marshall Islands NGO engaged in diabetes reduction suggesting a direct association between proximity to an airstrip and the consumption of an unhealthy diet (McMurray and Smith 2001). Even in the most remote island's stores are dominated by imported goods. Imports, especially food, have embedded islanders in wider worlds, with the humble village store the ubiquitous symbol and microcosm of globalisation.

Household food expenditures are dominated by imports. In Kiribati and Tuvalu, the two main calorie sources are rice and sugar, and household food expenditure is dominated by bread and rice (SPC 2011). More affluent households led the way. By the 1970s, stores were of significance in most Micronesian villages and food was often the main purchase. On Tamana atoll (Kiribati), where food production was never easy and droughts not unusual, 85 per cent of the average household's expenditure was on food: flour, rice, sugar, tinned meat and fish, biscuits and prepared foods (doughnuts, bread and cups of tea) were the most important, regularly purchased items (Lawrence 1977: 171). Households might go several days without solid food; 'if fish is available, it is eaten at any time of the day; if not morning or evening meals are likely to be toddy or *katokaben* (a mixture of grated coconut in toddy) and at any time during the day a dish of breadfruit, pawpaw or *bero* [a fibrous wild fig] or a flour or rice dish might be eaten' (Lawrence 1977: 178). On Ujae

> For breakfast the starch was flour made into zestless pancakes, uninspired donuts, bare-bones bread or flour soup… If I was extremely lucky I would be served instant ramen, starch in another form. For lunch there would be rice. It came in two varieties: plain or drenched in coconut oil. On the side there might be a cooked breadfruit. Or the whole meal might be replaced by two boiled bananas. Dinner was the same, perhaps with a fresh fish on the side (Rudiak-Gould 2009: 26).

On remote Nukumanu (PNG) by the 1980s, flour and rice had become the two main staples after coconuts, and such 'luxuries as coffee, tea, and sugar' had become necessities (Feinberg 1986). While pigs or chicken might be killed to accompany an occasional feast on these islands, these were not nutritious diets, and rice and flour were often scarce when the supply ship was late. It is scarcely surprising that store foods were a welcome diversion and addition. Fifteen years later, little had changed on Tamana though local foods were being consumed more frequently, since remittances had fallen; the same imported foods were purchased and 'chewing gum and tomato sauce' had now become 'basic essentials' (Lawrence 1992). A similar transition had occurred on Namu, where rice was even more important, when there was little or no pandanus or breadfruit, while rice, tea, flour and sugar were the four key purchased goods (Pollock 1996). Imported starches were taking over from taro and breadfruit. Sugar, as much as four–six tablespoons a cup, was added to coffee (Ahlgren et al 2014) On Nanumea too cordial, sweetened coffee or tea accompanied most meals and at ceremonial events in this century, local foods now competed with 'entire loaves of bread, tins of meat and fish, whole packets of biscuits or crackers… and several kind of cake and biscuits' (Chambers and Chambers 2018: 21). Ironically when Nanumeans visited the urbanised island of Funafuti, they took traditional foods for their nostalgic kin.

If 'modern' diets are poor, traditional atoll diets were rarely adequate, and Vitamin A deficiency—a cause of night blindness—was not unusual. Early nutrition studies pointed to substantial disadvantages particularly in Majuro, where food imports were already considerable (Murai 1954), but also on outer islands such as Ifaluk (FSM) where traditional diets had been retained (Bates and Abbott 1958). Mild deficiencies of vitamin A put children at risk of respiratory diseases and diarrhoea, both of which are a common cause of child mortality in Kiribati, where 15 per cent of children had Vitamin A deficiency in 1990 (Christensen 1995; Brewis 1996). In the mid-1990s, 55% of children in urban Majuro had at least moderate Vitamin A deficiency (Culpin 2017). Diarrhoea and parasitic diseases, often following consumption of contaminated food and water, are a major cause of morbidity, and dental caries is widespread (but underreported and neglected). Nutritional problems and partly consequential chronic disease problems have been documented in detail for FSM (Englberger et al.

2003), and are broadly similar elsewhere in Micronesia. NCDs have proliferated at epidemic levels for heart disease, diabetes, obesity and cancers, especially in urban centres, following dietary shifts and sedentarism, reaching globally extreme proportions in several states, as also in Polynesia, where they are the leading cause of death (Cassels 2006). In Micronesia, stunted infants can quickly become overweight children, and then obese adults, parts of the same nuclear family. Nauru has a world record diabetes rate of over 70% of adults. A third of all women and a quarter of men in RMI have diabetes. In Kosrae (FSM), 59% of adults are obese (Cassels 2006). In urban RMI as many as 37% of children aged between two and four are overweight with 13% obese by the time they are aged 13–15, while 13% of children aged 13 and over were malnourished; as elsewhere in Micronesia the population was experiencing both under- and over-nutrition (Culpin 2017). Iron-deficiency anaemia is reported to be 20% or greater in children and pregnant women in 15 of 16 Pacific island states (SPC 2010). Costs of reducing NCDs are high and a growing burden on national health systems. Inexpensive measures to prevent stunting, such as breastfeeding promotion and micronutrient supplementation, are overwhelmed by the need for money for expensive treatments for NCDs like diabetes. Space precludes discussion of alcohol, and its distinctive production, marketing and contribution to premature death, violence and anomie.

Imported foods have met needs for greater diversity, but at some financial and nutritional cost. Inadequate food safety laws and capacity to enforce them have resulted in imports of low-quality food (old, damaged and contaminated products, or with low vitamin and mineral content but high in fat, sugar and/or salt) that pose health risks. At the core of dietary disasters have been turkey tails, whose import began in the 1960s. So close is the correlation between high levels of consumption and diabetes that on Namoluk atoll (FSM) it has been labelled ‘turkey tail disease’ (Marshall 2004). Ignored in metropolitan states, cheap fatty meat products are forcefully marketed in the Pacific, along with other ‘ultra-processed food’ by transnational corporations and through chain stores, with minimal regulation (Moodie et al. 2013). Attempts to control the import of mutton flaps and similar products, at least in Fiji and Samoa, have been thwarted by threats of sanctions at the WTO, and regional and international trade agreements have disadvantaged nutrition in island states (Snowdon and Thow 2013). Food and beverage imports are consistently more than a third of the value of all imports, so contributing significantly to trade imbalances. The inability to develop and retain policies banning inappropriate imports may simultaneously worsen nutrition, health, dental health and the balance of trade. Rising food prices have undermined children’s nutrition, especially amongst the urban poor, where people turn to cheaper but less nutritious food. In urban areas, poverty partly explains such shifts, thus ‘any government that heavily taxes these products or bans them will suffer the ire of the working poor at elections and so the issue is largely avoided’ (Grynberg 2010: 34). That concern and acquiescence to WTO trade regimes have posed severe problems for urban nutrition especially.

4.7 Climate Change

The shift away from traditional staples poses particular problems for food security after hazard events. Hazards have both reduced the availability of local foods and hastened the transition to imported foods, as food aid has invariably come in the form of rice and other imported and processed foods. Atolls, where drought and king tides are not unusual, are particularly at risk, as islanders have no high (or even interior) land to retreat to if flooding occurs, and no distinct ecological systems. Increasingly, as urbanisation has proceeded, settlements are more at risk, where constructed on flood-prone areas and not sheltered by depleted mangrove groves. In RMI and FSM in the 2010s, several atolls have been inundated, with the loss of some land, crops and houses and saltwater intrusion into lenses. At other times food crops have been lost to drought and fresh water has had to be imported. Droughts and more saline lenses increase vulnerability to sanitation and hygiene problems. Increased temperatures will reduce agricultural productivity. Taro and breadfruit production in RMI have both been affected by cyclones and changes to water tables, the latter a function of ENSO events as much as climate change (Reti 2008). Such consequences are typical outcomes of what may become more common; climate change, and especially more frequent cyclones, is likely to reduce the viability of local agricultural systems even further. Repeated overwash increases salinity, especially in taro pits. In 2015, Typhoon Maysak damaged some 90% of homes in Chuuk (FSM) making at least 8,000 people homeless. Water sources became undrinkable, and outer islands sustained heavy damage to crops and houses. On Ulithi atoll (FSM), every building not made of concrete, and all crops, were severely damaged or destroyed. It was estimated that it would take a year before crops could be restored to production. The recent incidence of severe cyclones in the Pacific again suggests that this will no longer be an unusual occurrence in Micronesia, and will further influence increased both consumption of imported foods and migration from the region.

Changing sea temperatures and ocean acidification will alter fish and coral habitats, and storms damage such habitats, and potentially reduce fisheries productivity, but especially of small-scale coastal fisheries. These and other climate influenced changes will affect food availability and accessibility. If local foods give way further to processed foods the incidence of NCDs is likely to increase. Sea level rise will exacerbate such problems. Beyond existing socio-economic problems, it is a disconcerting future scenario for Micronesia.

4.8 Dysfunctional Policy? Diasporic Practice?

A suite of changes has transformed food production and consumption in Micronesia in the past half-century. These include changing production practices (notably the decline of subsistence), population increase and urbanisation, new attitudes to diets, modernity and status, access to imported foods, prices and pricing policies, aggressive marketing, the shift towards a corporate food regime, a decline in conservation practices, more 'sophisticated' resource (seafood) extraction (unaccompanied by sophisticated management), a 'coastal squeeze' and dependence on the state. Small islands, particularly those of Micronesia, have long faced nutrition and food security problems, hence, the existence of historical linkages between islands. Food shortages were not unusual in the past, and diets involved little diversity, so the ability to incorporate new foods was welcomed. That resulted in a transition, especially in urban centres, from local foods that were high in vitamins and fibre to imported foods that were tasty, but high in sugar, salt, fats and refined carbohydrates (Corsi et al. 2008). Diets diversified and worsened. Such processes have been largely resistant to tentative policy redirection.

Various constraints to increased local agricultural and fisheries production exist: greater population pressure on scarce coastal resources (with ecological degradation), land shortages (and land tenure issues), educational systems oriented to bureaucratic employment, high wages, no taxation on imported goods, limited marketing infrastructure, inadequate and expensive transport and few skilled marine scientists or agriculturalists. Agriculture and fisheries have been relatively neglected by island states, or focused on exports, and health promotion and nutrition units, where they exist, are underfunded appendages of something else. A widespread urban bias in development policy has contributed to outmigration from small islands.

Agriculture and fishing still provide valuable livelihoods, generate lease fees (in fisheries), enable some local market provision, and are one key to food security and nutritional wellbeing. Yet agriculture has disappeared in some Micronesian islands, and dwindled in most, while the same kind of cumulative downward spiral in agriculture has also affected fisheries. Biodiversity has declined. Complex human ecologies have become fragile with greater individualism (and rising populations) resulting in more disputes and less social cohesion. Depletion and over-exploitation of global fisheries have put increased pressure on island resources, with greater world demands for fish consumption. Climate change is likely to further reduce biodiversity, especially in atoll states (SPC 2011), and further threaten food security. Pronouncing agriculture and fisheries the background to the economy, and thus the key to food security, has never been successful.

As agriculture and fishing have become less likely to satisfy local needs for income generation, many individuals have moved into other economic activities, and diversification has brought greater occupational multiplicity, in order to construct a portfolio of livelihood activities to improve standards of living, part of a long history of flexible adaptation (Birch-Thomsen et al. 2010; Connell 2013). Diversity and multiplicity provide a more contemporary 'subsistence safety-net'. That has been necessary since governments have rarely looked favourably on rural people. Cultural, geographical and linguistic gaps that separate bureaucrats from farmers and fishers saw the latter viewed as illiterate, ignorant, backward and lazy and incapable of innovation, hence unworthy of policy intervention. Concerted efforts to develop and implement effective integrated rural and regional development policies have been absent. Policies appear in a token form on paper at the behest of international agencies. Rural bias and decentralisation of services in favour of fisheries, agriculture and integrated rural development is implausible. Households have had to diversify themselves to achieve development.

Moving towards ‘sustainable food security’ and food sovereignty requires both a reasonable degree of local production (supply) and scope for distribution and entitlements (demand) which centres on improved incomes, greater equity and effective market access: a focus on capabilities rather than calories. More effective markets, dependent on better infrastructure, with fairer prices—even though greater support for local food production might actually drive up domestic prices—are extremely difficult to implement in Micronesia. Food security becomes a problem of attaining adequate and sustainable livelihoods. It is not a question of how much food is produced—though that is of some significance—but whether those in need have adequate physical, social and economic access to food. Poverty is the main cause of food insecurity. Micronesia perfectly and tragically exemplifies the global context where healthier foods (and therefore diets) are costlier than less healthy options (Rao et al. 2013). Economic policies (such as tariffs or bans on imports) have been tried, but other than controls over a very small number of minor products, such policies oppose the interests of growing urban populations, who seek cheap food and defy WTO regulations. Single sector approaches are inadequate. Poverty reduction requires broad-based development, superior education, transport infrastructure, integrated health, agriculture and fisheries programmes, but at every turn the size and scale of deeply fragmented Micronesian states, weak governance and inadequate institutions, militate against economic growth and national integration. Producing and marketing local food in any volume is simply impossible. Constant policy suggestions that are aimed at education and consciousness raising are thus doomed to failure. ‘Regression’ is no-one’s priority, and has occurred only in adversity, as remoteness or income decline necessitate self-reliance: ‘a return to traditional lifestyles is not perceived as an option by many Marshallese’ (McMurray and Smith 2001: 139). Nor elsewhere. Ordinary Marshallese women (in the opening quotation), and others, well understand the problems, but the solution is elusive—since it cannot be achieved within RMI, or elsewhere in Micronesia, without economic development.

What may influence local production and consumption is the relationship between the price of imported food and local incomes. Home gardens are becoming more common in urban Tarawa (if not yet in Majuro or Funafuti) because urban households simply cannot afford the cost of imports. Simultaneously, on some outer islands, food production must be maintained because transport is too unreliable to guarantee a supply of processed food, but climate change will challenge this, and even encouraging a shift in attitudes in favour of urban gardening confronts ‘modern’ attitudes and land shortages.

The kinds of policies sometimes mooted that involve changing consumption patterns and increasing local productive capacity, to change living styles at given income levels using taxes and pricing policies, are unlikely to be chosen while emigration remains an unrestricted option (at least in RMI and FSM). Concerted comprehensive policy formation in loosely structured democratic states is already difficult. In Micronesian states, public regulation and market intervention are particularly weak, in an international context dominated by neo-liberal discourses and an emphasis on free markets and trade. In situations where the prospects for economic growth are slight, the difficulties are greater. Where dealing with malnutrition in its various forms should provide a bridge between economic growth and human development, achieving multiplicity, diversity and more flexible livelihoods—towards higher incomes and purchasing power—is unlikely to happen domestically. It is the peculiar irony of Micronesia that solutions to seemingly domestic Micronesian nutrition problems are most likely to be resolved only by more extensive migration and remittances. Micronesia is shifting towards a diasporic future—a pragmatic choice, following that already made through most of Polynesia—so that, more than in most other nations, food security requires a strategic and unusual global solution.

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Chapter 5
Modernisation, Traditional Food Resource Management and Food Security on Eauripik Atoll, Federated States of Micronesia

Andrew Scourse and Corinne Wilkins

Abstract The Micronesian atoll of Eauripik is one of the smallest and most remote populated islands in the Pacific. Its population live at a high density and combine subsistence production of tree and root crops with various forms of fishing from reefs, lagoon and ocean. Despite remoteness, significant changes have occurred in the management of food resources, alongside the introduction of imported foods and outboard motors and increased migration to urban centres amidst greater population mobility. The migration of men can result in local fish deficits and food shortages, where households have inadequate capital to purchase imported foods, but also results in the sending back of both imported foods such as rice, flour, tinned meat and instant noodles and new varieties of 'traditional' foods. Local foods, notably clams, are sent to migrants. Imported foods have tended to be consumed by immediate recipients while locally produced foods were shared more widely. The use of freezers to store fish has resulted in fishing being more individualised rather than undertaken cooperatively. Shortages of food may result from various factors, including hazard events and shortages of labour following illness, and have ensured that conservation practices, notably the management of coconuts, are retained. However, resorting to imported foods has weakened the significance of these strategies, and undermined the practice of sharing, emphasising the importance of understanding the social effects of 'modernising' projects for community food security.

Keywords Modernisation · Resource management · Yap state · Pacific · Atoll

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5.1 Introduction

Since the period of American administration which followed the second world war, modernisation and development have accelerated and driven great changes in even the remotest communities of the Pacific. Eauripik in Yap State of the Federated States of Micronesia (FSM) is one of more than 100 inhabited atolls in the Pacific. With one of the smallest populations in the region and only limited modernisation, it provides a good case study for developing an understanding of some of these changes, both at the community and the individual level. Its geographical isolation has particular implications for food security, making it a particularly pertinent example of issues specific to remote communities of this kind. This chapter discusses the changing management of food resources based on data collected during 7 months of fieldwork in 2001–02.

Eauripik atoll is one of the smallest continuously inhabited atolls in the Pacific and supports a particularly high population density of more than 1000 people per sq. km. The atoll is composed of three small islets, of which only Eauripik, the largest, is inhabited. The majority of cultivable land area is used for crops such as coconuts, breadfruit, bananas and taro and there is a variety of reef habitats around the atoll. These range from shallow, lagoon patch reefs and gently sloping outer reef slopes on the windward side to deep precipitous drop-offs on the leeward side. They support a wide variety of marine life and pelagic species such as tuna and mackerel, which are often caught close to the seaward reefs.

5.2 Community Structure

Understanding Eauripik's social structure is important to understand the context within which food and other resources are managed. In terms of food, the society has developed as a largely self-sufficient community with heavy emphasis on horticulture and fishing. Food ownership is principally the outcome of clan usufruct rights, or of food allocation made on the basis of 'household' composition. Household is used here in a very broad sense, usually comprising a number of dwellings as well as those living elsewhere who share the same food, such as those who have been adopted by existing household members. Adoption is quite common in Pacific communities and provides food claims to multiple households (Brady 1976). However, sharing is an important feature of Eauripikese society, as it is across much of Micronesia (Betzig and Turke 1986; Steager 1971). It is an important and frequently encountered mechanism which ensures that all social groups have claims to a variety of food resources.

Each member of the community belongs to one of the seven social groups, or extended households, called *ilets*, which form the basic structure for the 'ownership' and allocation of resources. The right to manage and harvest produce from crops such as coconut palms, bananas and taro is split among these groups, as is the produce from cultivation and fishing efforts which entail a pooling of labour and other resources such as boats and equipment. While the majority of land is owned by the chiefly clan and overall control rests with the chief, *ilets* use the land on a usufruct basis. Resource management within the *ilets* is carried out by male and female elders, known as the *ilalfat,* and although society is matrilineal, membership and involvement in *ilets* can come from a variety of events such as marriage, birth and adoption. This, in turn, means that each *ilet* has a strong network of social ties and has access to food and resources from a variety of sources. A specific example encountered during fieldwork illustrates the range of social connections which may become involved in the process of food distribution:

> A mother was counted in Peigefang *ilet* but her daughter was adopted by Peigieur *ilet* and was counted there both before and after she had her baby. The father of the baby was counted in Paugaluw but the parents decided the baby should be counted in neither of their *ilets*, but in Peigefang, where the baby's maternal grandmother was counted. The mother nursed the baby within Peigieur, where she and the father lived, but where only she was counted As a result, *ilet* allocations of food made at the community level counted the baby in Peigefang and the father in Paugaluw - both *ilets* where no family member was commonly resident. To compensate, equivalent shares were sent from both Paugaluw and Peigefang to Peigieur.

When this genealogical and social network is overlaid with sharing rights, based on pooled or combined labour, the sharing network can become extremely complicated. This does not imply that all sharing relationships must be recognised on every occasion, but it does provide a network through which many different sharing events occur over time. This is similar to the situation encountered by Steager on Puluwat:

> The network of secondary distribution [sharing] extends beyond the confines of the hamlet [the Puluwatese version of an *ilet*] to include both matrilineal and patrilineal kin. This extended network is not an obligatory set of exchanges or gifts but rather, a range of possible exchanges within which there are a multitude of possible choices. There is certainly an idealized distributional network, but this is derived largely from verbal behavior – for what people say they ought to do. As often as not, however, people do not follow these idealized norms. If this is brought to their attention, they simply shrug the matter off, explaining that in this or that particular case they chose to behave differently (Steager 1971:172).

This network, which may extend across large geographical areas due to inter-island marriages and emigration, is the basis for food and labour sharing events; this sharing, in turn, affirms social ties. In a discussion on emigration, one community member succinctly noted that 'everyone on the island is useful—even if only through talking' and also that people only become '*worthless'* if they emigrate and do not send produce or resources back to the island. This is illustrative of the importance allocated to sharing in regulating and maintaining community structure: someone may be unable to provide manual labour but is still a valued member of the community, whereas someone who leaves the island and does not maintain their 'sharing' ties is increasingly considered marginal.

5.3 The Impacts of Emigration and Modernisation

Migration, for example, through intra-island marriages, has, for a long time, had significant effects on the atoll communities of Micronesia (Damas 1986; Alkire 1965). More recently, the emigration of young and able-bodied individuals to port towns and other regional centres such as Guam as well as further afield—the 'institutionalised migration' referred to by Levin (1976) has become important across the region (Flinn 1994; Connell 1994, 1986; Marshall 1979). Indeed, as Connell (2015) notes:

> Extreme population pressure on resources was evident on many islands by the nineteenth century (Bayliss-Smith 1975). In the Tokelau atolls, migration was well established in life and thought; 'some of nearly every group of siblings must tahe ('emigrate') simply because the local resources are seen as insufficient' (Hooper and Huntsman 1973: 403–404). A century later, as in Solomon Islands atolls, migration had become 'a household strategy, by which migrants and their families (including those staying behind) diversify sources of incomes in order to minimize risks, such as loss of income and crop failures' (Birk and Rasmussen 2014). That has intensified as migration has been prolonged, expectations have risen and aspirations increased, and a culture of migration been established where migration was anticipated and normative (Donner 2002; Connell 2008, 2015).

Observations indicated that this was a growing trend on Eauripik, confirmed by the 2000 census (Government of the Federated States of Micronesia 2002), which showed a median age of 28.3 on the island compared to 20.9 in Yap state overall and 18.9 across the FSM, implying the loss of younger residents from Eauripik.

A specific example observed during our fieldwork illustrates the impact that even a moderate shortage of male labour can have in a gender differentiated society; at the 2000 census, just 42 men were recorded as resident on the island, compared to 71 women. For a 6-week period, one *ilet* had 7 mature females, 4 children and only 2 able-bodied mature males spread across its 4 subgroups. This *ilet* had no reserves of money with which to buy imported products and no direct access to a skiff, motor or fuel which might have facilitated fishing. In such situations either the women must fish, using the culturally acceptable methods open to them, as well as tend to the planted resources of the *ilet*, or the *ilet* must subsist on the small amounts of fish the men can provide. In this case, the *ilet* subsisted largely without fish, and thus largely without protein. The combined situation of having limited fish availability and not enough manpower to rectify the problem resulted in changes in eating habits. Greater quantities of food from alternative sources, such as rice, were consumed but, because of the lack of protein, appetites were not sated. This heightened demands on the harvestable planted resources.

Due to the geographical isolation of Eauripik, the small size of its population, and its comparatively recent modernisation, compared both to other islands in the region and more generally, it is possible to follow relatively closely how the community is being changed through its kinship ties to emigrated kin. The maintenance of kinship ties is one of the main mechanisms by which modernisation has occurred: emigrant kin sends back foodstuffs such as rice, flour, cooking oil and instant noodles as well as more substantial items such as fibreglass boats (skiffs) and outboard motors. These extended networks not only transmit products to the atoll, but also take produce from it. The most notable example was that of sending local clams to ‘off-island’ kin, a practice that was ultimately stopped as the level of ‘off-island’ demand was significantly reducing clam populations on Eauripik, endangering them as a local food source.

The *ilet* networks have had a significant impact on the development of food resources in Eauripik due to the pattern of emigration and kinship ties. A wide range of crop varieties have been introduced after being sent to the atoll by emigrant kin; community members identified six distinct types of banana that had been introduced, three types of introduced breadfruit, and three kinds of introduced coconut palm. Their origins were known, with some from as far away as Sonsorol in the Republic of Palau, hundreds of kms away. These introductions were viewed positively, with benefits including fruits with more flesh and fewer seeds, extended or different fruiting seasons and larger yields: introductions of this sort are a widespread trend in the Pacific.[1]

The impact of emigration on the food resources available to those living on Eauripik is also felt in other ways. One particular example is that of imported foodstuffs, which are not managed and distributed in the same way as local resources. Unlike local food, which is controlled by the *ilalfat,* the treatment of imported foodstuffs varied between *ilets* and, there were wide variations in the way in which management and usage rights were distributed within the *ilet* receiving the supplies. In some cases, the right to consume imported resources rested exclusively with the buyer or receiver, although they may be ‘advised’ with whom to share it. In others, the women of an *ilet* had the right to prepare imported food and treat it in the same way as local resources. Finally, the head male may have the exclusive right to decide when imported goods are consumed and the women of the *ilet* may have to seek permission before using them. In addition to this variation in distribution rights, some older *ilalfat* commented that they were not comfortable handling the ownership and usage issues attached to imported goods. On the one hand, they felt that they should have a say over the consumption of all food resources within the *ilet*. On the other hand, they were also aware of the concept of individual rights over purchased products and felt uncomfortable about asking to use them. The purchase of imported goods is in many cases individualised to an extent not previously seen on Eauripik. However, without the collective labour and vigilance that would have been invested in cultivating *local* resources, from planting right through to final harvesting, the grounds on which a claim for sharing imported goods could be made are less direct and well defined. The concept of individually owned food is both new and likely to become more central to community life.

Another area which demonstrates the effect of emigrated kin on resource management is the importing of machinery. Its impact has been significant on resource

[1]Dahl (1989) recorded such introductions in New Caledonia and Falanruw (1989) in Yap. The first author of this chapter has observed such introductions on Pohnpei (1999) and Pollock (1996) recorded them in the Marshalls, and so on across the Pacific. Falanruw (1989) noted that the diversity of cultivars of taro may have been important in Yap’s avoidance of outbreaks of disease caused by *Phytophthora colocasiae* which have damaged the less diversified taro crops of islands such as Bougainville and Manus.

management regionally. The introduction of freezers on nearby Woleai and Ulithi atolls, for example, has changed fishing practices. The cooperative labour traditionally associated with fishing has declined because individual catches can be kept for longer periods and therefore be kept for individual consumption. This, in turn, has changed the way in which fishing is done, with the focus now being on individual techniques.

On Eauripik, outboard motors and skiffs (small open-top fibreglass boats) were observed to have had a very significant impact on resource management. As on all outer islands of Yap, skiffs and outboard motors have become an important part of life and are likely to become pivotal given the local preference for using them and the fact that the skills required for constructing sailing canoes are disappearing. Skiffs are locally seen to have a number of advantages—they can be operated by one man, have more capacity, are quicker and are more controllable than traditional canoes. They do, however, cost a large amount to purchase and a considerable amount to run by island standards. Furthermore, they cannot be repaired on-island when they break down and thus may be out of action for several months. At the time of the fieldwork, only three motorised skiffs were in regular use, two of which were individually owned. Supplies of gas and oil were held by very few people on the island, usually three or fewer. With skiffs and gas acting as an important gateway to using both marine resources and food planted on the uninhabited islands of the atoll, there is reliance across all *ilets* on the skiff owners and those who own or can buy gas, and who can therefore unlock major portions of the different *ilet*'s resource entitlements. Several individuals suggested that perhaps counter-intuitively, wastage of resources on Weew, the main uninhabited island of the atoll, had increased with the increasing use of skiffs and gas for inter-island travel. This was because competition by other uses of skiffs had made foraging trips to the island more irregular.

In addition to the constraints imposed by the financial running costs of skiffs, their use has led to interesting outcomes through favouring particular types of fishing over others. Daily activity in Eauripik is genderised, as is commonplace across the Pacific, and most forms of fishing are male pursuits. Since fish are the major source of protein for the community, fishing is a highly developed skill on Eauripik: informants identified more than 60 different fishing methods. Possibly the most prestigious of these methods is 'trolling', where a fishing lure is trailed behind a boat that is travelling at speed. This technique is practised in the open ocean and principally results in catches of tuna and other large pelagic species.

The greater manoeuvrability and speed of skiffs, as compared with the sailing canoes, which would traditionally have been used, and the fact that they can be used even when there is little or no wind, has improved both the opportunity to use the technique and the chances of successful trolling expeditions, as has the introduction of more durable fishing gear, including nylon line, metal hooks and leaders. Nevertheless, the rate of return is still highly variable, as it is elsewhere, and fisherman may come back with little to show for their efforts. The popularity of skiff-based trolling, notwithstanding the uncertainty of the catch and the considerable financial outlay for gas, is clearly demonstrated by the fact that there is never any difficulty in collecting a team to go trolling when a skiff is being used. Furthermore, given the prestige gained from returning from a successful expedition, it is not difficult to appreciate why the method is so attractive. Because it is now possible to go trolling at any time and perhaps also because of the increased chances of success, trolling now accounts for a major proportion of fishing time. So while skiffs have reduced dependence on weather conditions, the focus on trolling has now become a limiting factor on how often the skiffs, gas and male labour, are available to help women harvest produce from Weew. The introduction of skiffs has therefore not only increased the time spent trolling (which is a method with very variable return) but has also changed the organisation of foraging on Weew, making it a more irregular activity. This illustrates some of the primary and secondary impacts of adopting new technologies, often brought in through kinship links, when they interact with social dynamics already present in the community, in this case, the prestige associated with certain fishing methods.

The absence of emigrants has other impacts on the management of food resources, beyond the products and machinery they send back. Some important fishing practices require large scale collectivisation of labour for example and are used particularly when all *ilets* need fish. The most commonly used of these methods is *mariug*, referred to in most previous literature as ‘leaf sweep’ fishing (e.g. Johannes 1981). This is a mixed gender fishing technique practiced on the reef flat, where all fish in a selected area (sometimes more than 30,000 m^2) is encircled with a rope wrapped in palm fronds, and then concentrated into a very small area by the repeated encirclement and consequent reduction in size of the rope circle. It is a very effective method of indiscriminately catching many species of fish (the authors were involved in one sweep that netted in excess of 700 fish). *Mariug* does, however, strongly affect the ecology of the barrier reef where it is used by removing many of the fish that tend to remain within a limited home range as well as large numbers of itinerant fish. It was locally recognised that fish populations of swept barrier reef areas take time to recover and that it was preferable not to sweep the same area twice or more in close succession, although it would be quite possible to do so. A reduced yield would be obtained and fish populations would be further depleted. In effect, the method can be employed with full productivity on only a limited number of occasions in any season. Additionally, sweeping any usable segment of the reef has cost implications for both labour and possibly gas, and there is also a question of topographic suitability for *mariug*. When labour is particularly short, it is not possible to sweep some regions, for example, the north side, with the result that alternative areas are exploited more extensively. This potentially increases the dependence on and importance of imported foodstuffs as well as risking degrading some reef areas, another significant impact of the relatively recent social trend of emigration of young and able-bodied individuals. Due to limited labour, the suitable marine areas for one of the most productive fishing methods are restricted and there is increased risk of resource degradation. The limited availability of labour also acts as a driver for increased dependence on imported foods.

5.4 Contingency Planning

There are many situations that can precipitate shortages of food which range from inconveniences to life-threatening events. Inconveniences might include a lack of available labour through illness, for example, creating a short-term shortage, perhaps measured in days, or a barren fruiting season (e.g. for breadfruit trees), which might affect one *ilet* for a season. Major events such as catastrophic typhoons can destroy almost all resources and contaminate the freshwater lens, which is vital for sustaining much of the vegetative growth of the atoll.

In addition to the day-to-day provision of food, an important part of the management responsibilities of the chief and *ilalfat* is to ensure that appropriate contingency planning is in place so that the community can survive satisfactorily in the event of a food shortage. There are 'coping mechanisms' for shortages present, both at the level of the community as a whole and at the level of the individual *ilet*, both overseen by the relevant individual in authority. Provisions for shortages are made in all *ilets* on Eauripik. In some, the rotating or static reservation of a proportion of the *ilet's* taro patches for emergency use is practised. A related custom is planting but avoiding the harvesting of *fille* plants (*Alocasia spp.*) until their tuber is either close to degradation, or until there is a produce shortage that merits their use. They are not a very desirable food because the edible corm is rich in oxalic acid which may numb and swell the tongue and pharynx, properties that assist conservation. Another strategy is the continual planting of crops with a relatively low space demand over which they will hold the first right, such as bananas and *fille*. The explanation given for doing this is that such resources often die, or are damaged and so having more than is actually necessary insures against the possibility of shortage while replacements are grown. The judgement as to whether a situation merits the use of contingency resources within an *ilet* is often the responsibility of the *ilalfat*.

Other coping practices that operate at the community level. Unused, fallen, 'sour' coconuts, both within *ilet* usufruct zones and the remaining communally claimed areas, are collected before they sprout and assembled into long thin piles which the authors termed 'coconut nurseries'. These caches of packaged copra can then, for a period of several months, be used as emergency food supplies if required, and are of use for the husk, as germinating coconut palms, or for other means for a lot longer. In place of the *ilalfat*, the chief has final control over the use of these nurseries.

Marine resources are rather less suited to cultivation and retention than planted resources specifically for contingency situations; however one example of this was observed. Beds of giant clams were deliberately cultivated and maintained in the shallows on the windward side of the islet. Returning fishing groups deposited clams in these nurseries that they picked up while fishing elsewhere on the reef. Empty clam shells were also replaced in large underwater collections following the local belief that this encourages the growth of new clams there. These beds were intentionally sited near the islet so that when the ocean and lagoon were too rough for fishing, clams could be taken instead. Further examples of rules established to ensure the conservation of marine resources in Yap state have been identified (Tafileichig and Inoue 2001).

These are some of the 'coping mechanisms' aimed at preserving both land and sea resources which have been built into the social structure of Eauripik. The chief has other powers relating to contingency planning; for example, he can impose wide ranging usage restrictions if he judges the situation merits them. The most prominent temporary measure of this kind in the minds of all community members was *sapet*, when the chief prohibits all collection of coconuts from the land owned by the chiefly clan for a period that may extend to many months. The measure is imposed when he considers the number of unused coconuts under trees to be getting too low or when he finds evidence that people are behaving in too liberal a manner in foraging for and using coconuts. A principal purpose of the rule is to ensure that, should there be a disaster which destroys many resources, the community could subsist on copra while a recovery got underway. *Sapet* is still very much current and was imposed for part of the fieldwork period, although the view was put forward by some that, in recent times, *sapet* has been of debatable efficacy. This is attributable, at least in part, to several contemporary trends. First, the previously imposed punishment for collecting copra in *sapet* is no longer in force and no publicised penance has replaced it. Second, a preference for imported 'convenience' foods such as rice, flour and tinned meat has developed alongside increased consumption of such foods. It was also argued that having stockpiles of such products meant that some *ilet*s are not so dependent on natural resources and no longer view *sapet* as being as relevant as it once was. These changing perspectives on management and storage of coconut supplies bear resemblance to observed changes in practice on other atoll communities such as in Kiribati, where purchase of food imports may be financed by sale of coconut stores, thereby reducing resilience and potentially increasing future dependence on food imports (Connell 2015). There are therefore a wide variety of contingency measures in the traditional system and while the introduction of imported foodstuffs has clear benefits it also challenges some of these mechanisms. In this last case, the presence of imported convenience foods challenges the traditional requirement to respect chiefly authority to conserve resources at a community level in case of an unexpected natural disaster.

The changing social context and the operational challenges of maintaining traditional resource management practices were illustrated quite clearly in one particular context. Both under the US and the independent FSM administrations, funds were provided for a sequence of development projects on Eauripik such as the construction of school buildings. Due to its remote location, all construction labour for such projects had to come from island inhabitants and the work was treated as a community endeavour. In keeping with the gendered nature of labour, much of the construction work was done by men, while women cooked for them and did auxiliary work such as fetching water. Aside from demands on the labour of individuals, these projects made demands on the natural resources of the atoll. Pigs, in particular, may be set aside for project completion celebrations a long time in advance of this happening and the responsibility for maintaining them is split among the *ilets*. Central to the running of these projects is the project management systems put into place by the federal bodies: target completion dates are set and inspectors come to assess the quality and progress of work. (They reserve the right to reduce or even withdraw support if the project overruns either in terms of time or budget). The imposition of these deadlines was a new phenomenon for Eauripik and could lead to temporary dependence on imported convenience foods and thus, implicitly, on money and off-island kin because, while a large proportion of the island's labour was used to finish the project, islanders were unable to go fishing or access off-island resources. On a small island such as Eauripik which has limited land resources, this quickly put a strain on indigenous food sources.

A specific example of this occurred when a reinforced concrete, walled church was being constructed with federal support. When deadlines or inspections were imminent there were periods when all the able-bodied men on the atoll worked full time on construction for three or more consecutive days, and during these periods very little, if any, fishing was done. Under the cover of darkness some women fished, using shore-based methods, which are seen as socially acceptable for women. However, the supply of fish did not support the needs of most *ilets*. When fish was not available, the entire community ate imported foods such as rice and flour and the produce of planted resources available on Eauripik itself, such as bananas and coconuts. It was not only people who had to change their eating habits: without fish remains to feed the pigs an alternative food had to be found for them as well. This came in the form of copra, which was collected from the patches used by the different *ilets* and this was done whether or not *sapet* was in force. Over time this had the effect of reducing the number of mature nuts left unharvested around the base of the palms and consequently reducing the land-based food reserves available for possible human consumption. This situation was at odds with the contingency planning measure of maintaining copra reserves for times of scarcity and was brought into sharp focus following Typhoon Mitag in March 2002, which damaged many breadfruit and banana trees on the atoll. At a community meeting after the storm, the chief declared that if copra continued to be harvested he would have to kill the pigs to reduce the demand on supplies, an action that would endanger the celebrations for the opening ceremony of the church.

This highlighted the irresolvable nature of the situation: the men would endanger the future of the project if they stopped working, yet both people and livestock needed food. Meanwhile, to continue relying on local resources such as copra contravened chiefly regulation and would deplete needed emergency supplies. In order to avoid these problems, the situation forced increased consumption of and reliance on imported convenience foods, predominantly sent by off-island kin and delivered on government ship visits. Again, this highlighted the sometimes opposing forces of traditional practices and more modern introductions to community life—in this case, federal supported development projects. Whilst these projects provide very real benefit for the community, they can also result in significant depletion of land resources or increased reliance on imported products which are only sporadically replenished.

5.5 Changing Concepts

A principal function of the island's social networks, as described above, is to provide members of the community with claims on different sets of resources so that people always have access to food. As we have emphasised, food sharing validates social ties and has a significant impact on the social standing of both *ilet* and individuals in the community; if someone does not share, he or she will have low social standing.

The introduction of new foodstuffs, both new crop varieties and imported products, has also impacted the conceptualisation of one aspect of food management in particular. Traditionally, it is considered shameful to indicate that one does not have enough to eat, expressed locally as 'low', as this implies either inadequate control over resources or a lack of sharing relationships through which one can obtain food. The understood meaning of 'low' in relation to food has, however, changed quite dramatically over time and this seems to have happened through several concurrent processes. First, the diversification of crop varieties has resulted in longer seasons, larger yields and greater variety of produce. This has smoothed availability, thus decreasing people's tolerances to scarcity and monotony, leading some *ilet*s to now consider themselves 'low' if they are lacking produce of a particular resource as opposed to lacking all produce. For many young people particularly, preferences are for imported foods such as rice, flour and instant noodles, and local produce may be overlooked in favour of these, partly as a consequence of the 10 years of food aid which followed Typhoon June in 1976. A similar situation shows similarity to that seen earlier on Piis atoll in Chuuk (FSM) (Severance 1980). Second, imported foods have introduced a dissociation between an *ilet's* conceived food status and the harvestable resources over which they have rights, compounded by the socioeconomic isolation of many *ilets* from these resources due to lack of inter-island transport. Third, the differing treatment of imported foods is also underlined by the fact that there is no stigma attached to admitting a shortage of imported foods within the *ilet*. *Ilet*s are often reliant on emigrant kin for the provision of such goods but this provision is irregular as it relies on visits of government vessels. There is, therefore, no implication of resource mismanagement in admitting a shortage of imported goods. How these recent changes in the conceptualisation of food resources will impact the continuing maintenance and evaluation of social ties and through that the underlying structure of how local produce is managed remains to be seen.

5.6 Conclusion

While few people live on atolls which are in every respect similar to Eauripik, the island does have a wider relevance. It is one example of a remote Pacific community with characteristically strong migration and federally supported development, two motifs that are common throughout the region. It is also a society which has traditionally and typically been gendered with fishing being male-associated and land cultivation female-associated activities (Alkire and Fujimura 1990). Furthermore, as in many remote areas of Micronesia, traditional social hierarchies involving chiefs and clan groupings remain extant. Whilst the details of community structures differ between islands, atoll communities all developed with a strong emphasis on management of local resources and have all faced the challenge of continuing modernisation supported by the state or international agencies. Therefore, when contemplating development projects or the provision of new, imported machinery or products, the possible social impacts and interactions with existing social structures and behaviour should be taken into account. For example, while the introduction of imported convenience foods can be positive for food availability in the short term, it can also create longer term insecurity and social tension through undermining the importance of observing previously practiced contingency measures and the loss of skills to manage and harvest local resources as well as the loss of desire to deal with them. This is particularly relevant when the infrastructure that supplies the imported convenience foods is not sufficient to guarantee a regular and dependable supply at all times or when, as was the case many years after typhoon June, a long period of external support comes to an end.

The isolated community of Eauripik is like many remote Pacific communities in that it has experienced significant emigration and received federal support through development projects and government vessel visits. Traditional management practices for food resources are deeply integrated into the social structure of the community. The custom of formalised sharing between kin has been a driver in introducing imported foods and machinery. Federally supported development projects can take labour away from harvesting resources locally and change the habits of new generations in relation to what they eat and the skills they have in tending to local resources. All of these drive the consumption of and dependency on imported goods. Attitudes to some aspects of resource management, such as contingency planning measures, are changing because the communal labour needed to fish, and grow and harvest local crops is not needed for noodles or rice, and the emergent concept of individual ownership is being applied to these new products. Imported machinery such as skiffs and outboard motors also alter food provision and access to resources and are dependent on the availability of gas. While crop introductions, imported foodstuffs, gas and development projects have very real benefits for communities such as Eauripik, they may challenge and change social practices, which may have negative effects on access to resources, contingency planning and maintenance of local resources, thus, affecting the overall food security of the community.

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Chapter 6
Framing Food Security in the Pacific Islands: Resilience in Malo, Vanuatu

Matthew G. Allen

Abstract Food security on Malo Island in Vanuatu is examined. All trade between Malo and the outside world crosses one beach on the neighbouring island. Data collected there, and on Malo itself, during fieldwork in 1997 and 2007 was used to describe the island's food system qualitatively and in terms of energy availability. Some 20 per cent of calories come from food imports, which could be easily substituted with surplus subsistence production in most years. The food system is then analyzed in terms of food security, with consideration given to past and present food systems in the context of economic and climatic variability. The contemporary food system is not only resilient, but far more so than prior to sustained contact with Europeans from around the turn of the 20th century. While there is some localized pressure on land caused by the dual drivers of population growth and extensive cash cropping, Malo people have been finding innovative solutions that have adapted "traditional" practices and institutions. Not all Pacific islands therefore fit the portrayal of the Pacific as an undifferentiated region characterized by vulnerability and food insecurity. It also demonstrates the importance of social resilience, in this case the adaptive capacity of traditional practices and institutions, to the sustainability of social-ecological systems.

Keywords Food security · Sustainability · Resilience · Agriculture · Vanuatu · Pacific

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6.1 Introduction

In his seminal article *Framing the Islands*, Greg Fry (1997) demonstrates the long-standing Australian practice of "framing" the South Pacific as an undifferentiated region, in which an abstract "Pacific Island state" and a mythical "Pacific Island person" are ascribed a particular set of characteristics and attributes. This construction of an undifferentiated Pacific Islands region is in defiance of the region's extraordinary socio-economic, cultural, linguistic and ecological diversity. The "new doomsdayism" that is Fry's primary focus—a powerful imaginary of the Pacific Islands promulgated in the 1990s by a coalition of Australian journalists, policy-oriented social scientists and policymakers—could easily have been cut and pasted from the depictions of "African" crisis and decay that came to the fore in the late 1980s. Both sets of images emphasized over-population, resource scarcity, economic decline, crime, violence, malnutrition, disease, pollution and land degradation. Both Africa and the Pacific were seen to be sliding "inexorably down the greasy slope of Rostowian growth into unprecedented poverty, backwardness, food-dependency and Malthusian crisis" (Watts 1989:1–2).

This chapter engages with and contests two contemporary and interrelated tropes that perpetuate both the construction of an undifferentiated "Pacific Islands" region and the ascription of doomsdaysist characteristics to the mythical "Pacific Island" and its inhabitant, the "Pacific Islander". The first trope, frequently encountered in the pages of consultancy and donor reports, as well as in academic journals, is that Pacific Islanders are becoming increasingly, if not entirely, dependent on the consumption of imported food to meet their nutritional requirements. The second trope, also popular in donor and some academic circles, is that Pacific Islands are especially vulnerable to the vicissitudes of the global economy and natural disasters, as indeed are the wider category of Small Island Developing States (SIDS) of which the Pacific Island states form a sub-set (Guillaumont 2010).

These tropes converge around the concept of food security. According to the Food and Agriculture Organization (FAO): "Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (FAO 2002). Proponents of what I call the "Pacific food insecurity narrative" claim that increased dependence on imported food, coupled with reliance on income derived from a narrow range of export commodities, has rendered Pacific Islanders more vulnerable to economic and environmental variability, thereby undermining their food security. A critical dimension of this vulnerability is said to be the erosion of "traditional" food supply systems, and accompanying social relations, which are seen as having been far more resilient than those in the contemporary Pacific Islands. At the same time, the changes in diets associated with the increasing dependence on imported food is producing a "Pacific-wide" epidemic of obesity and non-communicable diseases. The decline in resilience and self-sufficiency is often seen as a straightforward linear process brought about by the forces of colonialism and globalization (e.g. Hughes and Lawrence 2005:298–300; Campbell 2009:85).

Recent decades have witnessed a profusion of scholarship on the topics of vulnerability, resilience and adaptation, especially in the context of globalization and global environmental change (e.g. Bohle et al. 1994; Walker et al. 2002; Young et al. 2006). There has been growing recognition of the interaction between, and analytical inseparability of, social and ecological systems, giving rise to terms such as socio-ecological systems (Gallopin et al. 1989), social-ecological systems (Berkes and Folke 1998) and coupled human-environment systems (Turner et al. 2003). Pacific islands have long been the focus of studies of human-environment relations; and several recent case studies have explicitly applied social-ecological systems approaches to explore questions of resilience, vulnerability and adaptation (e.g. Fazey et al. 2011; Schwarz et al. 2011; Lauer et al. 2013). However, there has been a dearth of empirical work in the region that has specifically examined food security from a social-ecological systems perspective (cf. McCubbin et al. 2017).

Resilience and vulnerability are contested concepts. They are used across multiple disciplines, sometimes interchangeably and often with contrasting or even conflicting meanings (Gallopin 2006). Following Folke (2006), the definition of a resilient social-ecological system adopted here includes not only "the capacity to absorb shocks and still maintain function" but also the potential that disturbance can "create opportunity for doing new things, for innovation and for development" (Folke 2006:253). A vulnerable social-ecological system, by contrast, is one that has lost resilience, and, by implication, the capacity to adapt (Folke 2006:262).

This chapter presents a detailed analysis of the food system of a small island in northern Vanuatu (Fig. 6.1). Malo is an important case study for two reasons. Firstly it is reasonably typical of Island Melanesia. With a land area of 185 square kilometres, it is neither large nor small. Its population density of 23 persons per square kilometres is close to the average for Vanuatu and neighbouring Solomon Islands. In terms of access to urban markets, it is neither peri-urban nor extremely remote. Its annual rainfall is around average for Vanuatu and it is no more or less exposed to natural disasters, especially tropical cyclones and droughts, that beset Island Melanesia. Given its "median" status across these criteria, if the food insecurity narrative was going to ring true anywhere in Island Melanesia, it would be on Malo. However, we must acknowledge explicitly that there is a wide diversity of food security conditions in the Pacific Islands; and while it is argued that Malo does not fit the food insecurity narrative, many Pacific Islands do so.

The second reason why Malo is an important case study is because all trade conducted between it and the outside world passes across one beach on the south coast of neighbouring Espiritu Santo (Fig. 6.1). This provided a unique opportunity to survey and document trade—the export of fresh produce and cash crops and the import of "store-purchased" food—at the scale of the island.

Analysis of data from this trade survey and from agricultural surveys conducted on Malo during an eight-month period in 1997 (with follow-up informal interviews and observations conducted in 2007) indicates that an average resident of Malo derives only around 20 per cent of their calories from food imports and that, in most years, this could be easily substituted with surplus subsistence production. Moreover, through a careful reconstruction of the "traditional" food system in the context of the

Fig. 6.1 Location of Vanuatu and Malo Island. *Source* The Australian National University, College of Asia and the Pacific, CAP CartoGIS

island's agro-ecology, it is argued that the contemporary food system is resilient and certainly more so than that which, to the best of our knowledge, existed in the past. "Contemporary" here refers to the food supply situation as documented in detail in 1997 and re-assessed in 2007. "The past" refers to the period prior to the permanent settlement of European traders and planters on Malo around the turn of the 20th century, which set in train significant social and economic change on the island.

The new systems upon which contemporary food security on Malo relies raise some important concerns regarding long-term sustainability. Exemplifying both the trade-offs and feed-backs that characterize all food systems (Ericksen 2008a, b), the widespread planting of coconuts for cash income, around a third of which is used to purchase imported food, has produced localized land shortages that have been exacerbated by population growth. Local people have responded by increasing the intensity of land use for subsistence agriculture. This has been accompanied by innovations, such the increased use of high yielding species and cultivars, that have alleviated sustainability concerns associated with increasing land use intensity, at least in the short-term. Another response to these challenges has been to transact rights to land under the island's system of customary land tenure.

As well as providing empirical evidence that the food insecurity narrative does not apply to all Pacific Islands contexts, Malo demonstrates how local informal institutions (Ostrom 1990; Anderies et al. 2004), in this case the system of customary land tenure, can be critical for sustainable resource management. Moreover, given that the customary land system is embedded in a wider system of reciprocity and gift-exchange, involving both imported foods and staple food crops, the case study supports the proposition that the survival of socio-ecological systems has become "increasingly dependent *on the resilience of their social dynamics in contrast to their purely bio-physical dynamics*" [original emphasis] (Young et al. 2006:306).

6.2 Constructing Pacific Food Insecurity

Food dependency theorists of the 1970s and 1980s argued that the processes of colonisation and globalisation had created a situation of food dependency in Pacific Island countries (e.g. McGee 1975; Hamnett et al. 1981; Thaman 1990). At village level, it was argued that the need for cash had created new demands on farmers' time; and that, in addition to becoming "increasingly dependent" on imported food, they had shifted their production emphasis to cash crops and "less labour demanding staples" such as cassava, sweet potato and *Xanthosoma* taro (Thaman 1990:79). The new "dependent'" food systems were said to be inferior to the "traditional" agricultural systems of the Pacific Islands. The latter, with their large crop diversity at both the species and cultivar level, were seen as superior "in terms of diet, resistance to diseases, pests and natural disasters, and in seasonal availability of food stuffs" (Thaman 1990:26). It was also claimed that Pacific Islanders had become dependent, for their food security, upon the production of commodities, such as copra, which are vulnerable to fluctuations in international market prices.

These arguments were reflected in the reports of consultants and development agencies throughout the 1980s and 1990s, and were generalized not only to all Pacific Islands, but to rural as well as urban areas. For example, *The Pacific Way: Pacific Island Developing Countries' Report to the United Nations Conference on Environment and Development* stated: "Meanwhile, imported foodstuffs are becoming the *dominant supply* in rural as well as urban areas" [emphasis added] (Thistlethwaite and Votaw 1992:130). Similarly, the United Nations report *Sustainable Human Development in Vanuatu* stated: "Rural families are also *coming to depend* on purchased foods, due to land pressure, the shortage of food and the need for a cash income" [emphasis added] (United Nations 1996:68). Such framings of Pacific-wide food insecurity continue to resonate in contemporary scholarly and policy discourses. A recent analysis of the risks that climate change poses to the food security in the region acknowledges the geographical and ecological diversity of the region but nevertheless takes the "South Pacific" and "Pacific Island societies" as unitary frames of reference. A report, largely based on data from Fiji, is cited as evidence of increasing dependence on imported food "[a]cross the region" (Barnett 2011:S234). The forces of globalization, modernization and urbanization are seen as eroding the resilience of "traditional" food production systems:

> The problem is that these attempted shifts toward modern agricultural economies…have failed to deliver the kinds of resilient agricultural and food systems that developed countries enjoy, while at the same time undermining the resilience associated with traditional agricultural systems. Vulnerability is then manifested in the seemingly permanent transitional nature of Pacific societies (2011:S232).

This narrative of a linear decline into Pacific-wide food dependency and insecurity is reproduced in recent scholarship on vulnerability and resilience in the Pacific Islands. According to Campbell, for example:

> Pacific islands, and their inhabitants, are not essentially or inherently vulnerable. They were traditionally sites of resilience. Colonialism, development and globalisation have set in place processes by which the resilience has been reduced and exposure increased (2009:85).

It also finds currency in the growing scholarly literature on the links between food dependency, dietary change, obesity and non-communicable diseases. For example, an article examining globalization, food and health in the Pacific Islands argues that "once self-sufficient countries have become economically and food dependent on developed countries" and that "[i]mported rice, bread and noodles are now the leading Pacific staples, not local taro and yam" (Hughes and Lawrence 2005:298). These developments are said to have generated an epidemic of obesity and non-communicable diseases in "most Pacific Island Countries".

Reports by donor agencies and regional organizations reveal the extensive reproduction of the Pacific food insecurity narrative. According to a Secretariat of the Pacific Community (SPC) *Sustainable Development Brief*: "Remarkably rice and flour have now replaced root crops as the single most important source of starch and energy in Pacific Island Countries" (SPC 2013). An FAO report on climate change and food security in the Pacific Islands references a study from Solomon Islands demonstrating that "the majority of rural people still live and depend on subsistence food production and fisheries" (FAO 2008:7), but later reverts to the familiar shorthand:

> Basic staples such as rice and wheat for flour are key substitutes of traditional diets that are now part and parcel of a Pacific Islander's daily diet. This is a critical situation in terms of food security and nutritional security, given the volatility of international commodity prices (FAO 2008:9).

Amongst the considerable literature on food security in the Pacific, some explicit recognition of the critical importance of the region's socio-ecological diversity to analysis or discussion of food security does exist. Documentation associated with a 2011 meeting of Pacific Island Forum Economic Ministers on the "second international fuel and price shock" recognized that "there is significant heterogeneity across FICs [Forum Islands Countries] when it comes to the reliance on imported food" (Pacific Islands Forum 2011). It specifically drew a distinction between Papua New Guinea (PNG) and Solomon Islands, with low levels of reliance on imported foods, and Fiji and the Federated States of Micronesia (FSM), with high reliance.

McGregor et al. (2009) provide an especially nuanced account of food security in the Pacific Islands in the context of the global food price "crisis" of the late 2000's that proceeds from the observation diversity in the region's agricultural sectors must be taken into account in any assessment of food security. They delineated three broad analytical categories based on size, resource endowments and the importance of agriculture: the relatively large countries of Melanesia; the middle-sized countries of Polynesia; and the land-poor micro-states that are predominantly atolls. A wide range of food security conditions existed both between and within Pacific Island countries, which also meant that policy and donor interventions needed to be tailored to reflect these differences.

6.3 Methodology

Fieldwork was primarily conducted between April and December 1997, with a shorter visit in December 2007. No new data was collected in 2007. However, after spending several days on Malo and speaking with many of my original informants, I was able to ascertain that there had been more continuity than change in terms of the food supply system. One area where there had been important developments was land tenure. This is discussed in the final section of the article. Importantly, 1997 was a dry year everywhere in Vanuatu and was influenced by the El Niño Southern Oscillation (ENSO) event that caused extreme weather conditions throughout much of the Western Pacific and South-East Asia. The annual dry season on Malo (May to October) was particularly dry.

Twenty-five households were selected from three different villages (Nanuku, Avunatari and Ataripoi) in stratified samples. All of the productive food gardens belonging to these households were surveyed, a total of 253 gardens. Following the methodology employed by Allen et al. (1995) to investigate agricultural intensification in PNG, data were recorded on garden area, fallow length and type, cropping period, cropping sequence, crops planted and planting densities of the staple crops. Any staple crops that were harvested during garden visits were weighed. Vernacular names of cultivated species and varieties were recorded to assess genetic diversity. A trade survey was conducted on Naonepan beach two days a week for six months, recording the volume, in kilograms, of food crops and other products being exported from Malo to the fresh produce market in Luganville; and the volume of store-purchased food products such as rice, flour and tinned fish being imported.

Qualitative data on the production and marketing of smallholder cash crops was obtained through interviews and observation. Island level production data for copra and cocoa was obtained from the Statistics Office and the Vanuatu Commodities Marketing Board (VCMB) office in Luganville. Interviews were conducted with elderly men and women, to investigate the history of agricultural, social and economic change on the island, and with a wide range of other stakeholders including smallholder producers, traders and middlemen, market vendors, chiefs and church elders, agricultural extension staff and research scientists, and national and provincial level public servants.

Constraints of the methodology adopted here relate to questions of scale and socio-economic differentiation. Important differences exist between households in terms of the size of land holdings and access to income, which the stratified household samples attempted to take account of, alongside differences between the west and east Malo in terms of population density, land use intensity and access to urban markets. By extrapolating data to the scale of the island, which was necessary in order to compare subsistence production with island-level food import and cash crop export data, these spatial and inter-household differences were obscured. The description and analysis of food security that follows relates to the "average household" on Malo, and many households are better- or worse-off depending upon their particular circumstances. Intra-household differences along gender and inter-generational lines are similarly obscured.

6.4 Results

6.4.1 Land Use and Subsistence Agricultural Production

Malo is a geologically young island, characterized by a raised coral limestone plateau and a low-lying coastal fringe (Quantin 1981). Subsistence agriculture occurs on the plateau, which has fertile volcanic soils; whilst cash cropping, particularly coconut cultivation, is carried out on the coastal fringe (Fig. 6.2). Subsistence agriculture on Malo has three main components: the "shifting cultivation" of food gardens, arboriculture and animal husbandry. Shifting cultivation is the most important in terms of overall food production. A wide variety of food crops are cultivated in gardens, of

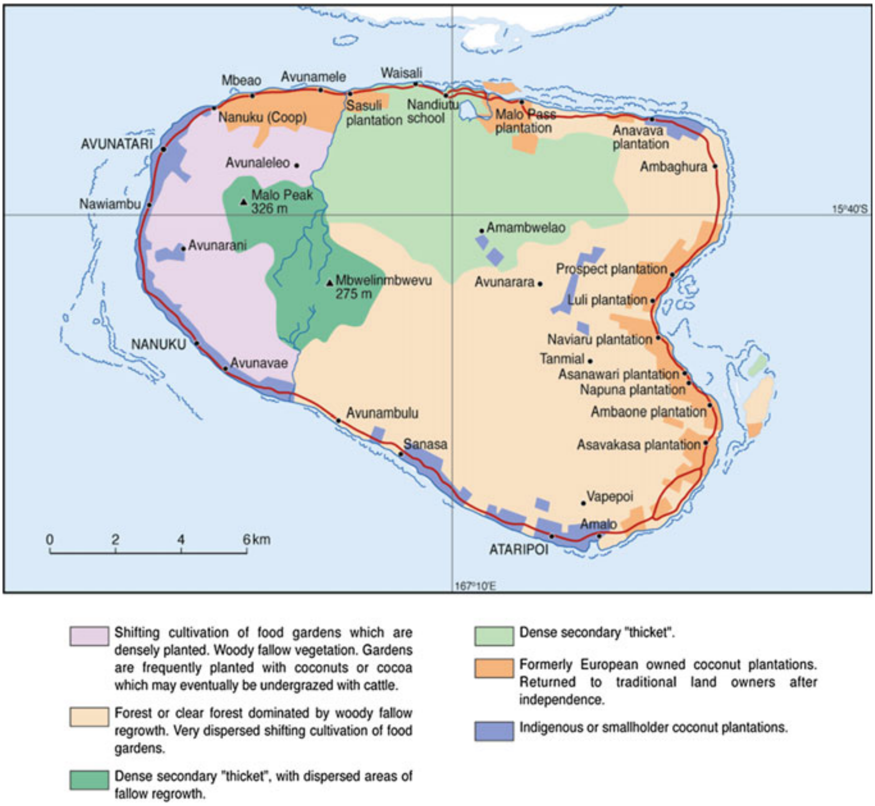

Fig. 6.2 Land use and vegetation on Malo. *Source* Adapted from ORSTOM vegetation map (Quantin 1981)

which the staple crops are, in order of importance: yam (seven species of *Dioscorea* in total of which *D. alata* and *D. nummularia* are the most significant), *Xanthosoma* or "Fiji" taro (*Xanthosoma sagittifolium*), banana (*Musa cvs.)*, cassava (*Manihot esculenta*) and sweet potato (*Ipomoea batatas*). Production from food gardens is supplemented by the cultivation of a wide variety of both indigenous and introduced fruit and nut trees of which breadfruit is most significant.

People on Malo classify gardens into two main types, depending upon which species of yam dominates in the first year of planting. *Alolona* gardens contain mostly *D. alata*, whilst *seremalavo* gardens are reserved for a particular group of cultivars of *D. nummularia* known locally as *marou*. The cultivation of *alolona* gardens dominates shifting cultivation throughout Malo. These gardens are cropped for between two and five years, with *Xanthosoma* taro and banana dominating after the first year yams are harvested; whereas *seremalavo* are generally abandoned after the second year of production. Fallow lengths for both *alolona* and *seremalavo* gardens average between 15 and 20 years in west Malo, and about 35 years in east Malo. There is a weak positive relationship between land use intensity and population density. The highest land use intensities occur around Avunatari village (on the west coast), where in some instances fallow lengths are as low as four or five years. This area also has the island's highest population densities.

As in many Pacific Island contexts, a proportion of the food grown on Malo represents social production: "goods produced for the use of others in prestation, ceremony and ritual, hence having a primarily social purpose" (Brookfield 1972:38). Particular cultivars of *D. alata*, known locally as *bisu* and *bisiroi*, are cultivated both for home consumption and for use in the exchanges that take place at customary ceremonies such as weddings and funerals. These exchanges are critical to the reproduction of social relations on Malo, including the establishment and reproduction of rights to customary land.

The customary land system is patrilineal and patriarchal, with men holding primary rights to land, usually inherited from their fathers, whilst women only have rights to land by virtue of their relationships to men either as unmarried daughters or as wives who have been properly "paid for" with cash and/or pigs. The system also permits transfers in rights to land in exchange for cash and/or pigs. For a man to ensure his rights to land, and those of his children and grandchildren, there are certain exchange ceremonies that he must perform. In addition to bride price, payments must be made for each male and female child. The ceremonies associated with bride price and "looking at the child" payments involve exchanges of *bisiroi* and *bisu* yams between the host and his guests.

Production estimates were made for four species of yams, *Xanthosoma* taro and banana (Table 6.1). *Xanthosoma* taro is the most important food crop in west Malo, whereas *marou* yams are the most important in east Malo. The other three yam species are the second most important food crops in both east and west Malo. The net production of these staple crops is equivalent to 2.1 kg and 2278 kcal per person per day in west Malo, and 2.5 kg and 2667 kcal per person per day in east Malo.

Table 6.1 Production estimates of the three most important food crops on Malo (kg per person per year)

	West Malo	East Malo
Alolona yams (*D. alata*, *D. rotundata* and *D. esculenta*)	421.6	422.2
Marou yams (*D. nummularia*)	20.7	469.1
Xanthosoma taro	516.9	227.8
Banana	193.0	318.5
Total gross production of starchy staple crops	1152.2	1437.6
Total net production[a]	**763.8**	**904.9**

Notes [a]Net production was calculated by estimating, for each crop, the average weights of planting materials and edible portions, and deducting these from the gross production estimates
Source Author's surveys

6.4.2 Income and Trade

Malo's monetary economy is, with three exceptions, dependent upon the export and sale of products to Luganville. The exceptions are remittances, wages paid to workers employed on Malo such as teachers and health workers, and the sale of a very small amount of fresh produce at the market in Vila (the capital, on the island of Efate). Estimates were made of the volume and value of exports of the three most important components of the Malo cash economy: copra, cocoa, and fresh produce marketed in Luganville. Producers mostly sold their copra and cocoa to middlemen on Malo, in both processed and unprocessed forms, who on-sold to the VCMB office in Luganville. Fresh produce, by contrast, was sold at the Luganville market by the producers.

Copra is the most important export commodity for Malo, as it is for Vanuatu as a whole. Cocoa is relatively insignificant though its importance has increased over the past 35 years or so. Although the income earned from the sale of goods at the market in Luganville is relatively small, most goes to women who make up the vast majority of market vendors, whereas income from copra and cocoa flows mostly to men. The estimated per capita annual income from these sources in 1997 was A$242 from copra; A$47 from cocoa; and A$35 from fresh produce.

The Naonepan trade survey sampled 50 different marketed products. The five most important in terms of value were all significant food crops on Malo: *marou* yams, green coconuts, bananas, 'wild' yams and *Xanthosoma* taro. However, only about two per cent of total staple crop production was exported for sale at the market in Luganville. Twenty-six 'store-purchased' food products were imported during the sample period. Rice was the most important of these, accounting for approximately 65 per cent of all imported food. In a nutritional sense, these imported products were collectively equivalent to about 538 kcal per person per day.

6.4.3 The Contemporary Food Supply Situation

When the net production estimates for the main staple crops are aggregated for all of Malo and adjusted to account for exports, they become equivalent to 2.2 kg and 2420 kcal per person per day (Table 6.2). These production estimates relate only to the main staple crops and do not consider the contribution from many minor foods. Their inclusion would increase the figures to around 3 kg and 3000 kcal. By contrast, imported food products provide about 538 kcal per person per day on Malo. According to the WHO "moderately active" adults require approximately 2600 kcal of food energy per day (WHO 1979:29). Since all the store-purchased foods imported to Malo are consumed, an assumption not necessarily true for subsistence production, about 20 per cent of Malo people's daily energy requirements are coming from imported foods, and the rest are coming from subsistence production.

Table 6.2 Daily energy available from staple starchy crops produced on Malo, from imported 'local' foods, and from imported 'store purchased' foods in 1997

Energy Source	Quantity available (kg per person per day)	Energy available (kilo-calories per person per day)[a]
Staple crops produced on Malo (*D. alata*, *D. esculenta*, *D. rotundata,* 'marou', *Xanthosoma* taro and banana)	2.2	2420
Imported 'local' foods (*D. alata*, *D. esculenta*, *D. rotundata,* 'marou', *Xanthosoma* taro, island taro, banana and sweet potato)	0.01	14
Imported 'store purchased' foods (rice, flour, sugar, tinned fish, tinned meat, salt, oil, wine etc.)	0.2	538
Total	**2.4**	**2968**

Notes [a]Energy content was calculated using food composition tables (Dignan et al. 1994)
Source Author's surveys

6.5 Discussion

6.5.1 Consistency of Food Supply Over the Course of a Year and Resilience to Minor Climatic Events

The pre-contact agricultural system on Malo was dominated by *D. alata* and *D. nummularia* yams and breadfruit. Yams were grown in a shifting cultivation system and it seems likely that there was only a single planting of these crops before gardens were returned to fallow. Breadfruit and 'strong' and 'wild' yams (*D. nummularia*) filled the annual shortage in the supply of 'soft' yams (*D. alata*). *D. alata* yams were available between March and September; with the latter month roughly coinciding with the commencement of the *D. nummularia* harvest, which continued until late December/early January. Breadfruit then became the staple crop, and with the use of preservation and storage technology, its availability was extended until the commencement of the next year's *D. alata* harvest. The supply of food throughout the course of the year was also enhanced, as it is today, by the cultivation of a large diversity of indigenous fruit and nut tree species that have different and often overlapping fruiting periods, thereby contributing to an almost year round supply of fruits and nuts.

The strength of such agricultural systems, in terms of food security, partly reflects the extraordinary genetic diversity of the crop base (Weightman 1989, Thaman 1990). On Malo, this diversity was particularly marked for yams and breadfruit. I collected vernacular names for 156 varieties of yams (mostly *D. alata*), but actually observed only 62 of them in gardens and other locations. This indicates that fewer cultivars are cultivated today than in the past, and that a significant number have effectively been lost. The practical outcome of such a diverse crop base, coupled with the use of yam storage and breadfruit preservation, was that the supply of food on Malo was reasonably consistent over the course of a year.

However, in terms of food security, the system described above contained a number of weak points: crucial times in the production cycle when even very short term or minor climatic perturbations could jeopardize or disrupt food supply for several months. The planting time for yams in *alolona* gardens was one such weak point, since yams are planted at the beginning of the wet season, but if the rains do not come as expected, even if delayed by only a month or two, as in 1997, the entire *alolona* yam crop could fail. The breadfruit season, which coincides with the beginning of the cyclone season (November to April), is another such weak point: a minor cyclone early in the breadfruit season could have compromise food supply for several months.

These weak points and gaps in the food supply system have been largely removed by the adoption of new food crop species, particularly Fiji taro, but also cassava, sweet potato, banana cultivars and a large range of fruit trees and other minor food crops; and by the adoption of cash cropping and the associated ability to consume imported food. Compared to the annual yam and the seasonal breadfruit, Fiji taro and cassava are essentially perennial crops that have added an underlying consistency to the supply of food over the course of a year. These crops "can be stored in the ground after maturity until they are needed, giving flexibility and security by filling in gaps in the food supply" (Bourke 1990:152).

Consequently people are no longer entirely reliant for their food security on the overlapping production patterns of a number of seasonal and annual crops, whose production is vulnerable, at critical points in the production cycle, to minor climatic events.

Malo villagers consume imported foods, particularly rice, for a variety of reasons: they are quick and easy to prepare, compared with local staple foods, and can be stored for a long time. Most importantly, imported foods are always available to be purchased and consumed, being non-seasonal, as is the supply of copra which provides the primary source of income to purchase them. In this manner, consumption of imported food also contributes to an underlying consistency to the annual supply of food; a consistency which did not really exist in the past.

6.5.2 Resilience to Major Climatic Events and Economic Variability

Some evidence suggests that "traditional" food supply systems in Vanuatu were vulnerable to the impacts of severe cyclones and prolonged droughts. Dorothy Shineberg, writing about the nineteenth century labour trade, mentions both cyclones and droughts as "push" factors that encouraged people from Vanuatu to volunteer as labourers on plantations in Queensland and elsewhere (Shineberg 1999). Her analysis of labour ship journals found frequent reference to the numbers of voluntary labour recruits increasing as a direct consequence of severe cyclones and extended droughts.

It is reasonable to speculate that, during the pre-contact period, a severe cyclone or an extended drought, such as that experienced in Vanuatu in 1983 (Weightman 1989:4), would have had a devastating effect on food supply and may even have resulted in deaths. However, this is no longer the case, at least not on Malo. The new crops, particularly Fiji taro, cassava and sweet potato, are considerably more tolerant to cyclones than yams and breadfruit. Moreover, the ability to convert the drought tolerant coconut into cash and use it to purchase imported food means that people have a "safety net" to fall back on in the event of a prolonged drought destroying food gardens. The usefulness of coconuts during times of drought was demonstrated during the severe drought and frost that simultaneously affected PNG in 1997 when, for rural households in some lowland and coastal areas, "making copra was the only way to earn money for the purchase of basic food items" (Inape and Humphrey 2001:76–77).

During the unusually dry period on Malo in 1997, which coincided with the *alolona* yam planting, many informants stated that they were fortunate to have coconuts because if the yam crop was to fail entirely they would still be able to produce and sell copra and use the proceeds to purchase food. Increased copra production in the short term was possible since under normal conditions on Malo copra is not produced at full capacity, as evidenced by a constant surplus of fallen coconuts. Even in the unlikely event that people were unable to increase their production of copra, they could decrease or defer their consumption of other items (since only a third of cash income was spent on imported foods). Some people also had cash savings that could be spent on food. The greater the diversity in sources of income available to villagers, the greater the benefit for food security. For example, although coconuts are drought tolerant, they are quite vulnerable to cyclone damage, but Malo villagers would still be able to earn some cash income through the sale of fresh produce in Luganville. Indeed, if food supplies were particularly low as a result of the cyclone, low energy—but relatively cyclone tolerant—food crops, such as brassicas and cucurbits (such as squash and cucumbers) could be converted into high energy foods (that is, rice or even root crops) through the market.

The food dependency argument, that a fall in the international market prices of commodities such as copra and cocoa, or an increase in the prices of imported staples such as rice, would result in food supply problems because people would be unable to afford to purchase food, is problematic in the case of Malo. First, people are not dependent on food imports to meet their daily energy requirements. Even in the extremely unlikely event that cash income from all sources fell to zero (as a result of economic rather than environmental variability), or imported rice became entirely unaffordable, people would still have enough food to eat. Second, the Malo economy is no longer reliant on copra as its sole export commodity. The diversification into cocoa and more recently, fresh food marketing, has fortified the overall food system against economic variability.

6.5.3 Sustainability Issues

Although contemporary resource exploitation systems on Malo are adequate in terms of food security, they raise some concerns with regard to the long-term sustainability of the key resource—land. The widespread cultivation of coconuts is of particular concern. An on-going trend in land use on Malo, particularly in west Malo, has seen the gradual replacement of gardens by semi-permanent stands of coconuts. Smallholder cultivation of coconuts has moved beyond the coastal fringe, encroaching further and further into the plateau, an area that was previously the exclusive domain of shifting cultivation. The spread of coconuts has been complemented in west Malo by rapid population growth, resulting in shortages of gardening land.

People have found innovative solutions to these problems. Subsistence production has been intensified by reducing fallow lengths and increasing cropping periods, steadily evolving over the past 60 years. If left unchecked, such intensification would eventually result in declining soil fertility, but it has been offset, at least in the short-term, by the adoption of new, high yielding crops (both species and cultivars). In addition to the adoption of New World crops such as *Xanthosoma* taro, cassava and sweet potato, there has been considerable movement of yam cultivars within Vanuatu itself; the most frequently planted cultivars now being those that are relatively high yielding. One example is the cultivar of *D. alata* known as *tumas*, which is said to have originated from Ambrym Island, nearly a hundred kilometres away. *D. rotundata*, the third most frequently cultivated yam on Malo, is a West African species only recently introduced to Vanuatu, and adopted on Malo in the mid-1980s. Again, this is due to its relatively high yield, as well as its short growing period and tolerance of dry conditions.

Although the socially important yam cultivars of *D. alata*, known locally as *bisiroi* and *bisu*, have been partly replaced by higher yielding species and cultivars, they still rank in the top ten most frequently planted yam cultivars on Malo. Moreover, they continue to occupy pride of place in the gardens and are accorded the most care and effort at all stages of their production. Indeed, most of the changes in subsistence agriculture on Malo have occurred around a core of intensive yam cultivation, which has declined in terms of garden area, but nevertheless remains focused on producing high quality tubers for use both in gift-exchange and the family kitchen. A similar study on Bellona Island (Solomon Islands) found continuity in "the importance of yam gardens for cultural identity, in helping maintain the social institutions that still provide an important social safety net" (Birch-Thomsen et al. 2010:38).

Another solution to land shortages in west Malo has been for people to acquire access to land on east Malo where population densities are much lower and surplus land available. Three of the eight households sampled at Avunatari village had acquired access to land in east Malo, which they used for both gardening and cash-cropping. These land transactions took place under the customary land tenure system on Malo, which allows for transfers of rights to land in exchange for pigs and/or cash, a system that probably developed as a "practical mechanism for the addition of in-migrants from other islands or from other areas of Malo, into the land group" (Rubinstein 1978:78). The system was flexible enough to allow the movement of large numbers of people from the interior of the island down to the coast to live near the Presbyterian missions that were established in the late nineteenth century. It was also flexible enough to enable the migration to East Malo in the 1940s and 1950s of people from Malakula and Ambrym, who also acquired land from the customary owners.

The final major solution to land use problems on Malo has been economic diversification. The adoption of cocoa and, more recently, fresh food marketing, means that people are no longer entirely reliant on copra for their cash income. Other recent examples of economic diversification include the production of minor cash crops such as vanilla and pepper and the sale of fresh seafood to Chinese merchants in Luganville. Further diversification away from copra production may result in a reduction in the rate of new coconut plantings, providing some relief in areas where land is short.

6.6 Conclusion: Policy Implications and the Ethics of Framing Pacific Food Insecurity

The Malo case study presents solid empirical evidence of an island that does not fit the Pacific food insecurity narrative, and also affirms that Melanesia is generally relatively food secure compared to Polynesia and Micronesia which better fit the food insecurity narrative (McGregor et al. 2009). It provides further support for the argument that policy and donor interventions must be tailored to reflect diverse food security contexts, even within individual countries (and also inter- and intra-household differences in vulnerability to food security).

The Pacific food insecurity narrative also raises an ethical challenge. Unlike the doomsday framing, which, as Fry demonstrates, was underpinned by a neo-liberal agenda for intervention and reform, the food insecurity narrative appears to be driven by largely benevolent motives, but nevertheless perpetuates some key elements of the doomsday framing that are both demeaning and belittling of Pacific Islanders. Contemporary academic portrayals of the Pacific food insecurity narrative have a clear lineage to the "food dependency" theorists of the 1970s and 1980s. To some extent recent depictions of Pacific food insecurity and vulnerability can be read in the vein of classic world system or dependency theory; the progressive annihilation of the cultural and socio-economic diversity of the periphery by the homogenizing forces of global capitalism. The food insecurity narrative entails a denial of agency on the part of Pacific Islanders who are seen as hapless victims of a monolithic global economy that is inexorably destroying their "traditional" social and agricultural systems; a perspective that Marshall Sahlins famously parodied as "despondency theory" (1999). Yet for the Pacific Islands, as for other developing-country contexts, these structuralist perspectives have received sustained critique. Geographers such as George Curry (2003) and John Connell (2007, 2013), have demonstrated how Pacific Islanders, much like those on Malo, have exercised considerable agency in their engagements with capitalism and other global phenomena as they seek to forge locally meaningful "hybrid" socio-economic forms.

Malo can best be read in this post-structuralist frame. Over the past century or so people on Malo have adopted innovative solutions to their land use, food supply and sustainability challenges that have adapted "traditional" practices and exchange relations, here those relating to agriculture and customary land, while simultaneously responding to new opportunities presented by globalization. Birch-Thomsen et al. reached a similar conclusion in their study of Bellona: "land use practices are closely linked to societal institutions and their ability to adapt and make use of changing socioeconomic conditions" (2010:39). Far from rendering them more vulnerable and food insecure, people on Malo have succeeded in improving their food security in the context of economic and environmental variability. In the words of John Connell: "Hybridity and livelihood diversification insulate islands and islanders from environmental and economic shocks" (2013: 254).

Malo's system of customary land tenure has been a critically important institution for supporting food security and livelihoods. Yet by 2007 land deals were being done with foreign property developers for customary land on the adjacent island of Aore, much of which is owned by Malo people, all part of a "land grab" that has seen the registration and leasing of customary land throughout rural Vanuatu, but especially on Efate, Santo and Aore, much of which has been sub-divided and sold to foreigners (Scott et al. 2012; McDonnell 2016). While Malo may be spared due to its greater distance from urban amenities, these land alienations threaten the viability of an institution whose fluidity, flexibility and inclusivity has provided the basis for resilience in the face of change and uncertainty. The registration and leasing of customary land is arguably the most pressing food security policy issue in Vanuatu.

The food insecurity narrative, and the doomsdayist imaginary that preceded it, continue the longstanding Western practice of framing the Pacific Islands in terms of "deficits"—smallness, remoteness, and so on—as Epeli Hau'ofa (1994) demonstrated so aptly (Jolly 2007). While the Malo case study cannot speak for other Pacific Island contexts, read alongside recent studies that have highlighted the resilience of island scale social-ecological systems in the Pacific (see Gough et al. 2010; Nunn et al. 2017; Perkins and Krause 2018), it encourages us to reframe Pacific food security in a more positive light: an opportunity for Pacific Islanders to deploy innovative approaches that are tailored to their particular circumstances and entail the adaptation of place-based cultural, agricultural and socio–economic practices and institutions in response to the challenges and opportunities presented by globalization and environmental change.

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Chapter 7
Postharvest Loss in Fruit and Vegetable Markets in Samoa

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Abstract Postharvest loss is of particular importance in small Polynesian nations such as Samoa, due to declining smallholder participation in agriculture, a greater reliance on food imports, and wider dietary-based population health concerns. Efforts to remediate loss is currently being impeded by little information as to the current levels of horticultural loss in Samoa or the factors contributing to this loss. In this study, we quantified the commercial postharvest loss of 23 horticultural crops at the Fugalei central municipal market on the Island of Upolu Island, Samoa, using direct weighing. The mean postharvest loss was further determined in all six municipal,

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community and private fruit and vegetable markets on the Samoan Islands of Upolu and Savai'i using vendor and farmer-trader surveys. Postharvest horticultural loss in the Fugalei municipal market was 6.2% (determined by weight) and 13.3% (based on vendor recall). There was no significant difference between the mean postharvest loss in fruits compared to vegetables. The highest level of daily postharvest loss (5–22%) was observed for soursop, papaya, Tahitian lime, mustard cabbage and choko. Negligible loss (<1%) was observed in limes, vi (*Spondias dulcis*), eggplant, long bean, soa'a (plantains), lemon, cherry tomato, cucumber, pumpkin, ginger. The level of postharvest loss varied across the municipal, village and roadside markets surveyed, with higher losses in non-urban markets. There was no significant difference in the level of postharvest loss between any of the three urban markets in the Apia region. With most horticultural production located less than 20 km from the municipal market and little evidence of in-transit damage, transport logistics were unlikely to be an important contributor to loss. Low and sporadic consumer purchasing behaviour resulting in protracted market storage at high tropical ambient temperatures was the central contributor to observed losses. The potential importance of low consumer purchasing activity and the proportion of commercial vendor to transient farmer-trader in each of the markets is discussed in terms of being a possible contributing factor to the resulting levels of postharvest loss and market variability.

Keywords Food security · Postharvest loss · Food waste · Marketing · Horticulture · Samoa

7.1 Introduction

Postharvest horticulture loss in less-developed transitional economies has received increasing attention in recent years from the perspective of benefits to food and nutritional security and rural livelihood development (Kader 2004; Parfitt et al. 2010; Hodges et al. 2011; Kitinoja et al. 2011; Kitinoja 2013; Affognon et al. 2015). In seeking to quantify and remediate postharvest loss, much of the current academic literature has focussed on sub-Saharan Africa and the Asian region (Weinberger et al. 2008; Kitinoja and AlHassan 2010; Mashau et al. 2012; Oelofse and Nahman 2013; Kaminski and Christiaensen 2014). The combination of high levels of horticultural loss and social disadvantage that can translate into significant population impact justifies such attention (Mwaniki 2006; Brown et al. 2009).

In comparison, very few studies have documented postharvest loss in the South Pacific. Pacific horticultural value chains are predominantly structured around smallholder and semi-subsistence farmers employing low-intensity production systems. Postharvest handling infrastructure is commonly inadequate, with farmers and market vendors often constrained by limited postharvest capacity and knowledge (Veit 2009; Fink et al. 2013; Underhill 2013; Underhill and Kumar 2015). It is not surprising then, that postharvest loss is considered to be too high (Cocker 2000; Veit 2009; Lazar-Baker et al. 2011). In one of the few recent studies undertaken in the South

Pacific region, postharvest loss in municipal markets in Fiji was shown to be between 2.5 and 10% (Underhill and Kumar 2014). Comparatively, low postharvest loss in the Underhill and Kumar (2014) study was attributed to short intra-island transport distance coupled with rapid market throughput. Given no comparable studies elsewhere in the region, it is unclear whether such losses and associated contributors are atypical or representative of the wider Pacific region.

Postharvest loss is of particular importance in Polynesian nations such as Samoa. High rates of non-communicable diseases (NCD) symptomatic of transient dietary patterns away from the consumption of fresh fruit and vegetables (Seiden et al. 2012; Ichiho et al. 2013), declining smallholder participation in agriculture (Samoa Bureau of Statistics 2009) and a greater reliance on food imports (McGregor et al. 2009), have collectively focussed attention on the need to improve horticultural productivity and postharvest handling efficiency. The South Pacific region now has one of the highest rates of obesity and diabetes in the world, with NCDs accounting for more than 70% of all deaths in the region (Tuitama et al. 2014; Hawley and McGarvey 2015). In an attempt to revitalise the horticultural industry and achieve pro-health outcomes, the Samoan Government launched the *Fruit and Vegetables Development Strategy for Samoa* in 2009. Reducing postharvest loss was identified as a core priority. The lack of information as to the extent of current commercial horticultural postharvest loss in Samoa, where along the value chain loss is occurring and possible contributory factors to postharvest loss in Samoa, have impeded efforts to improve postharvest handling systems to date.

In this study, we sought to quantify postharvest loss for a range of domestically grown fruit and vegetable crops at the main central municipal market in Apia, Samoa. A wider survey-based assessment of postharvest loss for all of the fruit and vegetable markets on the Islands of Upolu and Savai'i was further undertaken to assess any spatial variability and to validate postharvest loss. The potential influence of transport conditions, packaging and market storage as possible contributors to postharvest loss were also examined.

7.2 Methodology

7.2.1 Direct Weighing of Postharvest Loss in Fugalei Market

Postharvest loss of fruits and vegetables in the Fugalei municipal market in Apia, Upolu Island, Samoa (Fig. 7.1) was determined using the direct weighing method as previously reported by Underhill and Kumar (2014, 2015). While this study preceded the release of the Food Loss and Waste (FLW) Protocol (2016), this method was also consistent with key elements of the FLW standard pertaining to the quantification of food losses. A total of 18 commercial market vendors were assessed. Sampling was undertaken in February and March 2015 to ensure the inclusion of seasonal fruit crops in the study and validated with further sampling in May 2015. Postharvest loss was defined as the percent of product removed from the municipal market component

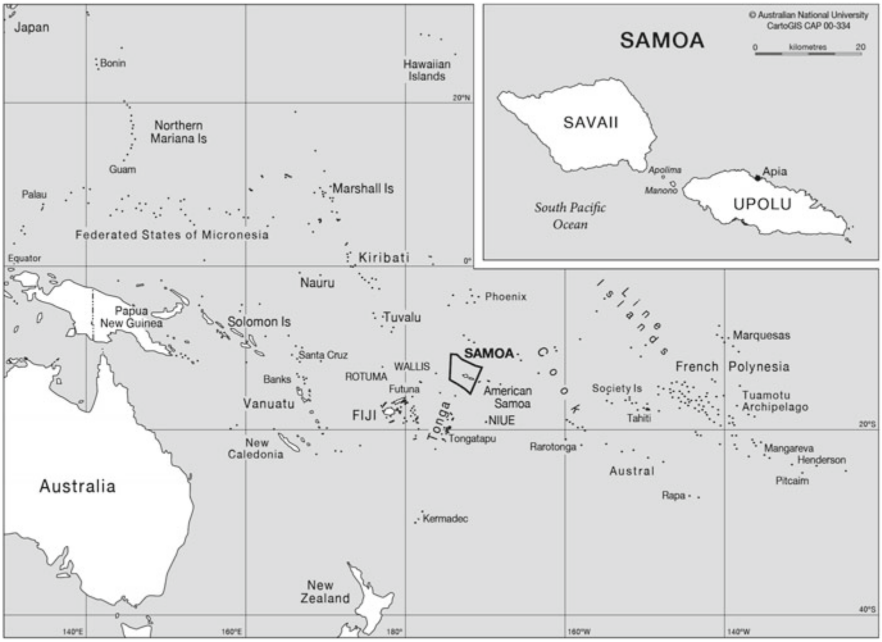

Fig. 7.1 Map of Samoa showing the relative location of Upolu and Savai'i Islands. *Source* Australian National University, 2018

of the commercial supply chain. While on-farm harvesting loss was not directly assessed, most horticultural product in Samoa is packed in-field, with sorting and grading only occurring once the product arrives at the markets. As such, municipal market loss reported in this study also includes transport loss and potentially on-farm loss. Fruit and vegetable postharvest loss was determined by first measuring the weight (g) of all product for sale at the commencement of each trading day per vendor and per commodity type, using a 5-kg commercial-balance calibrated hourly. Plastic bins were then provided to each market vendor to retain potential postharvest loss incurred during the day. Prior to the commencement of each trading day, commercial loss from the previous day was segregated accordingly to crop, individually weighed, and the loss was calculated as a percent of initial consignment weight (expressed as daily postharvest loss). The risk of sampling error due to postharvest loss being otherwise disposed of by the vendor, was determined in discussions with each vendor on a daily basis. Where there was any uncertainty, data were not included. Mean daily postharvest loss was calculated on the basis of the mean consignment loss per crop relative to the number of vendor trading days that the product was observed for sale. This study did not assess post-municipal market loss due to consumer waste or the destination of loss (i.e. product that was commercially harvested but not transported to the municipal market or the end-destination for product removed from the market).

The Fugalei market was selected as the study site because it is the largest and most important municipal fruit and vegetable market in Samoa. As each vendor had up to ten types of fruits or vegetables for sale at any given time, and vendor loss was segregated per crop, mean crop-specific losses were also determined. Due to low-frequency trading of some crops (product being sold by a single vendor or only traded on a limited number of days) postharvest loss is only reported for the 23 most-traded commodities. In total, this study involved 41 vendors-trading days (number of vendors sampled × number of days when sampling was undertaken) with a total of 3166 kg of product assessed.

7.2.2 *Survey of Vendor Postharvest Loss*

A survey of vendor postharvest loss was conducted in all of the municipal and private fruit and vegetable markets in Samoa. A total of 58 market vendors and farmer-traders from the Fugalei municipal market (33) (Fig. 7.2a, b), Taufusi private market (10) (Fig. 7.2c, d), Vaitele market (8), Afega village market (5) (Fig. 7.2e, f), Saleimona roadside market (2), and the Salelologa municipal market (8) (Fig. 7.2g, h), were interviewed to determine postharvest loss per vendor, and to identify those crops with the highest perceived net loss. While this study preceded the release of the FLW Protocol (2016), the survey method used was consistent with key elements of the standard pertaining to food loss surveys. Interviews were informal and undertaken in local Gagana Samoa language, interviewer administered and involved vendor recall of horticultural market loss specific to their own enterprise. The Fugalei, Taufusi, Vaitele, Afega and Saleimona markets are located on the main island of Upolu. The Salelologa municipal market is the sole fruit and vegetable market on the island of Savai'i (approximately 22 km from Upolu) (Fig. 7.1). The Fugalei, Taufusi and Vaitele markets were all located within the greater Apia region and represent urban markets. Given the absence of wholesale fruit and vegetable markets in Samoa, all the markets surveyed were retail markets. The close proximity island of American Samoa was not included in this study. The 58 vendors and farmer-traders interviewed represented at least 90% of the vendors and traders present at the time of sampling. This study did not include self-service roadside stalls, which are commonly observed on the island of Savai'i, or commercial retail shops that also sell fresh fruits and vegetables.

7.2.3 *Postharvest Supply Chain Factors*

Product storage conditions at the Fugalei market were recorded using TinyTag Transit-2 temperature loggers (Gemini Dataloggers, United Kingdom) which were placed adjacent to one of the vendor stalls for the duration of the first market sampling period (Feb 2015) with temperature (°C) recorded every two seconds.

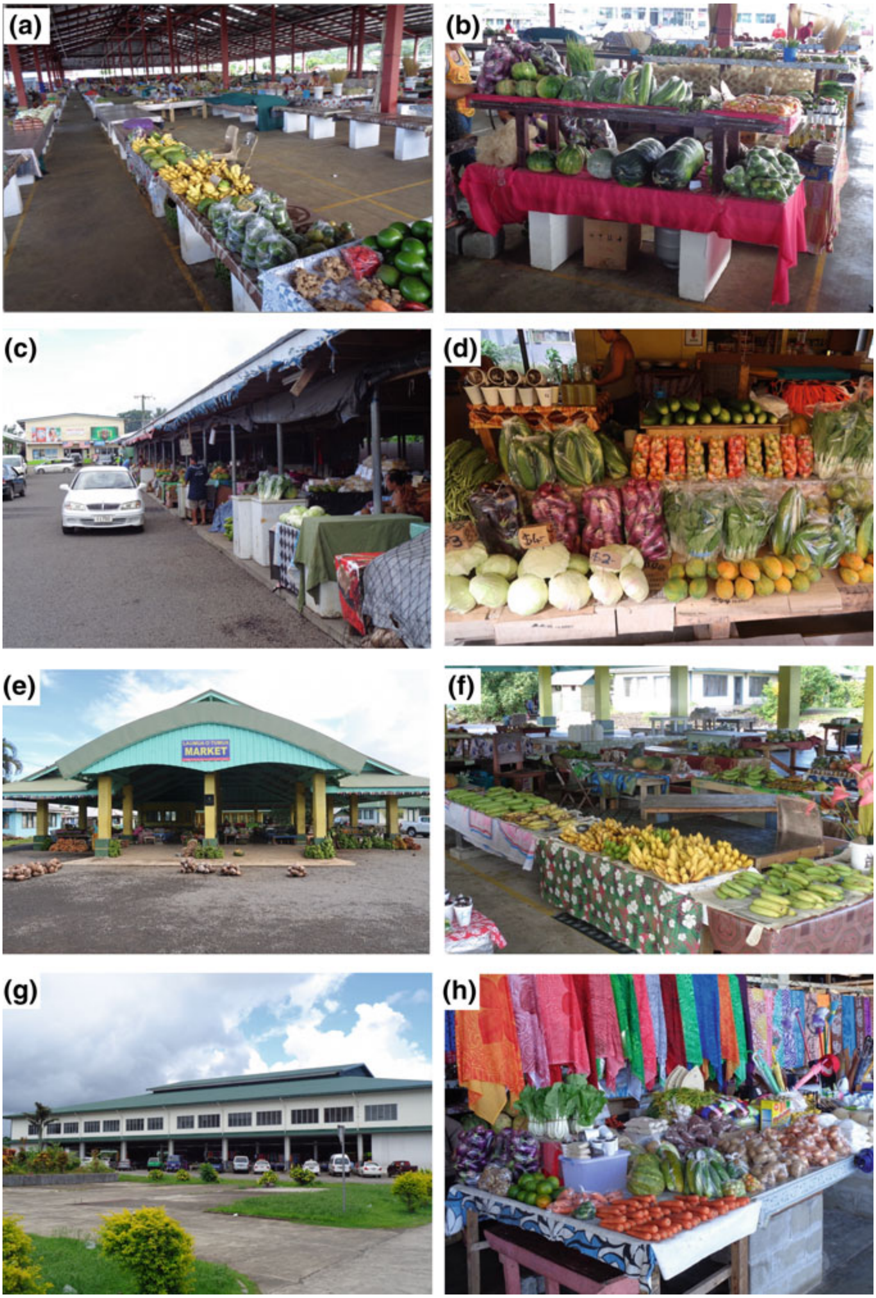

Fig. 7.2 Horticultural markets in Samoa. **a** and **b** Fugalei municipal market in 2015 **c** and **d** Taufusi private market **e** and **f** Afega village market in 2015 (also called *Laumua o Tumua*) **g** and **h** the Salelologa municipal market, Savai'i Island

The transport distance from farm to the Fugalei market was measured using Google Earth™ distance calculator. Production location for each commodity and the mode of transport (truck, bus, taxi/car) was determined in discussions with individual market vendors. Likely transport routes were identified on the basis of the shortest anticipated road path, known commercial transport routes and local bus routes. Mean transport distance was calculated to account for multiple source locations.

7.2.4 Data and Statistical Analysis

Analysis of fruit and vegetable (combined) loss on a fresh weight basis (in kg) was undertaken using a one-way analysis of variance (ANOVA). Analysis of municipal market vendor survey loss was undertaken using ANOVA followed by Tukey-Kramer multiple comparison test (with consideration for uneven vendor numbers between markets). The relationship between weekly postharvest loss and the time that fruits and vegetables were stored in the municipal markets was determined using both linear and polynomial regression analysis.

7.3 Results

Mean daily postharvest horticultural loss at the Fugalei central municipal market was calculated as 2.3% for vegetables and 2.5% for fruits (Table 7.1), based on the direct weighing method. There was no significant difference between postharvest losses in fruits compared to vegetables. The amount of postharvest loss varied between crops. The high levels of daily postharvest loss (5–22%) were observed for soursop, papaya, Tahitian limes, mustard cabbage, and choko. Negligible loss, at less than 1% of the daily loss, was observed in limes, vi (*Spondias dulcis*), eggplant, long bean, soa'a (plantains), lemon, cherry tomato, cucumber, pumpkin, ginger. No postharvest loss was observed in pumpkin, ginger or Samoan orange (Table 7.1).

On average, the product was stored at the Fugalei municipal market for 2.89 days, with 2.64 days for vegetables and 3.13 days for fruits (Table 7.1). Given that there was no refrigerated storage infrastructure at the Fugalei market (or in any of the Samoan municipal or village markets), storage time in the market is indicative of the length of time taken to sell the product, or for the product to be removed from sale due to spoilage. Storage time did vary between crops. The mean storage time for soursop and vi was 5 days, whereas pak choi, cherry tomato and choko were held for 1.38, 1.50 and 1.70 days, respectively (Table 7.1). Perishable or higher value crops such as leafy Asian vegetables and cherry tomato tended to be stored for a shorter time. Figure 7.3 shows the percent of individual consignments subjected to prolonged market storage. On Monday, all products for sale had been in the market for 3 days, with up to 33–57% of the product for sale on successive days having been held in the markets for 4 or more days. On Friday, 12.7% of product for sale

Table 7.1 Postharvest loss, transport distance and storage time for a range of fruits and vegetables in the Fugalei municipal fruit and vegetable market, Upolu, Samoa

Commodity	Mean daily postharvest loss[a] (%)	Meantime at municipal market[b] (days)	Mean postharvest loss (%) (a * b)	Volume assessed (kg)
Soursop	21.8	5.33	100	20.88
Papaya	12.4	2.13	26.4	208.53
Tahitian lime	8.8	3.91	34.2	43.80
Pak choi	6.8	1.38	9.4	93.50
Mustard cabbage	6.1	2.25	13.6	12.37
Choko	5.1	1.70	8.7	109.71
Chinese cabbage	2.8	2.25	6.4	35.16
Head cabbage	2.5	3.5	8.9	559.25
Chilli (small)[c]	2.5	4.13	10.4	5.96
Avocado	2.2	3.09	6.7	147.57
Pineapple	1.9	1.94	3.7	45.60
Banana (all types)	1.0	1.94	2.0	125.18
Lime	0.6	3.80	2.3	51.96
Vi (*Spondias dulcis*)	0.5	5.00	2.5	36.89
Eggplant	0.4	3.36	1.3	316.45
Long bean	0.3	1.29	0.4	108.40
Soa'a (Incl. Plantains)	0.3	2.86	0.7	14.52
Lemon	0.2	2.80	0.7	84.60
Cherry tomato	0.01	1.50	0.02	26.47
Cucumber	0.01	2.50	0.03	119.65
Pumpkin	0.0	2.35	0	885.31
Ginger	0.0	4.55	0	23.11
Samoan Orange (navel type)	0.0	3.3	0	82.49
All vegetables	2.3a	2.64	6.0	2272.22
All fruits	2.5a	3.13	7.7	894.33
Total	2.1	2.89	6.2	3166.54

Note [a]Vendor postharvest loss is the mean percent loss per crop, per vendor, per trading day, averaged across on three sampling periods
[b]The number of trading days across all vendors that a specific consignment was presented for sale
[c]Chilli (Thai pepper or birds eye chilli type) has been included due to the high number of vendors (11) selling the product
Values followed by the same letter are not significantly different at $P < 0.05$
Postharvest loss for garlic chives, melon, okra, rambutan, green mango, spring onion, passion fruit, sweet potato and snake bean were determined but not presented due to the low frequency of trading (single vendor or less than 4 vendor trading days)

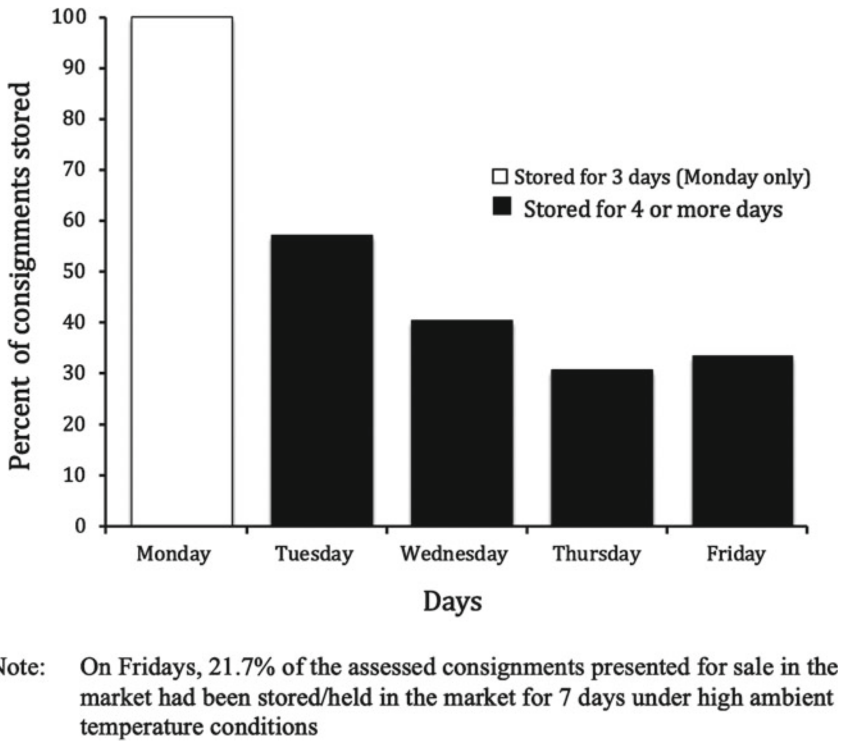

Fig. 7.3 Percent of individual vegetable and fruit consignments subjected to prolonged storage (3+ days) at the Fugalei central markets, Samoa

had been in the market for at least 7 days. While in the Fugalei municipal market, the product was stored at 26.5–32 °C (in February) (Fig. 7.4) and 24–27 °C (during March and April—data not shown).

Table 7.2 A comparison of vendor postharvest loss at the Fugalei municipal fruit and vegetable market, Samoa, February verses March 2015

	Sampling period	Mean daily postharvest loss (%)
All vegetables	Feb	1.4a
All vegetables	March	2.2a
All fruits	Feb	2.6a
All fruits	March	2.2a

Notes Values followed by the same letter are not significant different at $P < 0.05$

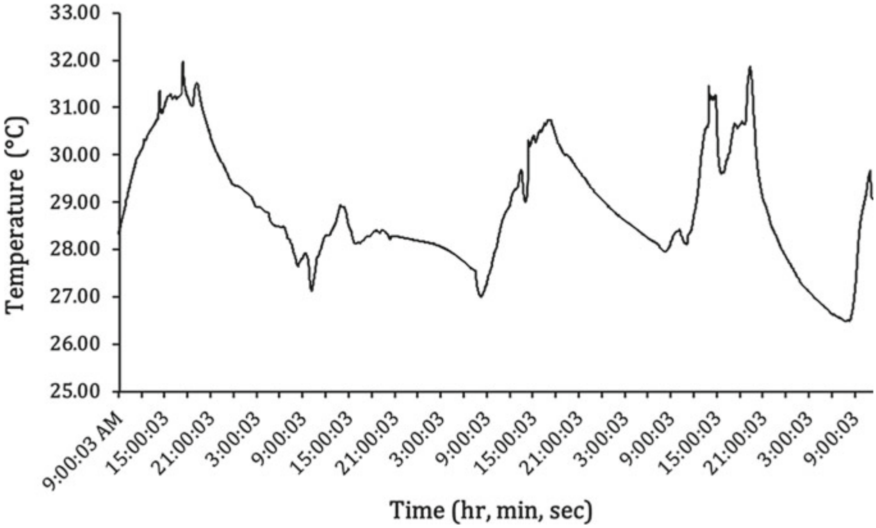

Fig. 7.4 Temperature at the Fugalei market, Samoa, during the primary assessment period of February 2015

Given extended market storage, the commercial postharvest loss is best represented when the daily postharvest loss is combined with the mean number of days that product was stored in the markets. Accordingly, the mean postharvest loss for vegetables was 6.0% and for fruits 7.7%, with an overall municipal market loss (for all crops) of 6.2% (Tables 7.1 and 7.2). The most vulnerable crops to high levels of commercial postharvest loss were soursop (100%), Tahitian limes (34.2%) and papaya (26.4%). Leafy vegetables such as pak choi, Chinese cabbage, cabbage and mustard cabbage had moderate to high levels of postharvest loss (6.4–13.6%).

When crops were separated according to high or low postharvest loss crops, there was a significant and high correlation between the length of market storage and the amount of postharvest loss (Fig. 7.5). In high loss crops, postharvest losses followed

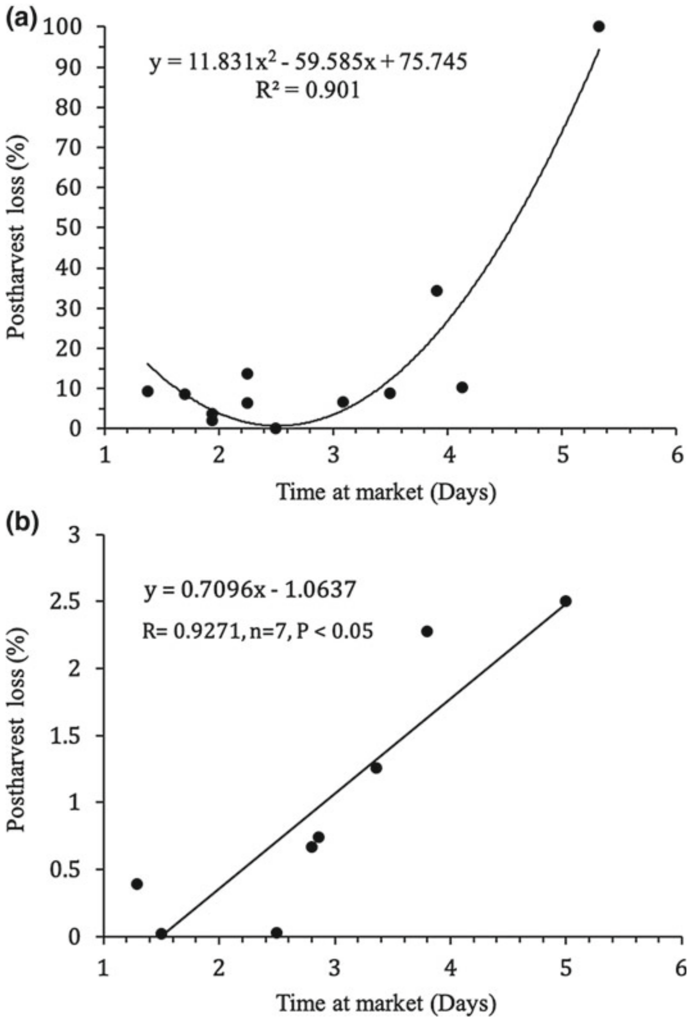

Fig. 7.5 Relationship between time in the market and weekly postharvest loss for fruits and vegetables in Samoa **a** high postharvest loss crops using quadratic polynomial **b** low postharvest loss crops using linear regression

a quadratic polynomial with a dramatic increase after 3 days. In low postharvest loss crops, the overall loss was small (less than 5% loss), it progressed slowly and followed a linear relationship (Fig. 7.5).

Product transport distances from farms to the Fugalei market were short, often less than 20 km (Table 7.3). While horticulture product is sourced from across Upolu Island, most of the horticultural production is located close to the fruit and vegetable markets. The Aleisa region, where most commercial-scale farms are located, is less than 15 km from the Fugalei municipal market. Longer transportation distances (up to 52 km) were limited to taro and taro leaf sourced from remote villages in the south-east and south-west regions of Upolu. The types of postharvest transport used by farmers to supply horticultural market are shown in Fig. 7.6.

The most common reason for the product being removed from commercial sale was due to postharvest disease or being over-ripe (Table 7.3). In leafy vegetable crops,

Table 7.3 Transport distance, storage time and packaging type for a range of fruit and vegetable crops at the Fugalei municipal market, Samoa

Commodity	Mean transport distance[b] (km)	Packing options used	Reason for postharvest loss
Soursop	15.37	Nil	Disease (rots), over-ripe
Papaya	15.57	Nil	Over-ripe, rots
Tahitian lime	28.33	LDBP bags	Rots, over-ripe (yellow)
Pak choi		LDBP open sleeve; nil[a]	Trimming
Mustard cabbage		Nil	Trimmings, insect damage
Choko[c]	25.15	Nil[a]; LDBP bags	Disease (18%), appearance (7%), size/physical damage (10%), insect (65%)
Chinese cabbage	11.54	Nil	Trimmings (wilting leaves)
Cabbage	17.42	Nil	Trimmings (wilting leaves)
Chilli	19.11	LDBP bags[a]; nil	Disease (rots)
Avocado	14.47	LDBP bags[a]; nil	Over-ripe, disease (rots)
Pineapple	13.06	Nil	Disease (rots), over-ripe
Banana	15.79	Nil	Over-ripe, disease (rots)
Lime	14.95	LDBP	Disease (rots), over-ripe
Vi	14.83	Nil	Field damage
Eggplant	16.43	LDBP bags[a]; nil	Disease (rots)

(continued)

Table 7.3 (continued)

Commodity	Mean transport distance[b] (km)	Packing options used	Reason for postharvest loss
Soa'a	4.53	Nil	Over-ripe, disease (rots)
Lemon	15.80	Nil[a]; LDBP bags	Disease (rots), over-ripe
Long bean	16.31	Nil[a] LDBP bags	Desiccated
Cucumber	28.33	Nil; LDBP Bags[a]	Over-ripe
Cherry tomato	16.98	LDBP bags	–
Pumpkin	12.86	Nil	–
Ginger	22.14	Nil	–
Taro	34.21	Nil	–
Taro leaf	52.23	Nil	–

Notes LDBP (low density biodegradable plastic) bags. Only biodegradable plastic bags can be used in commercial retail in Samoa
[a]Indicates most common packing used. (–) Indicated nil postharvest low or limited sample volume
[b]Mean transport distance is the distance from farm to the Fugalei markets, accounting for multiple source locations and number of consignments
[c]There was a large single consignment loss (33.4 kg) allowing for a more detailed assessment of the underlying contributors of postharvest loss

the loss was associated with daily trimming of the leaves, rather than net crop loss. A large single consignment of choko allowed for a more detailed segregation of the underlying contributors, with most loss due to on-farm damage (insect damage 65%; appearance 7%, and size/physical damage 10%) symptomatic of limited on-farm sorting and grading.

Plastic packaging was commonly used for small and high-value crops such as chilli, eggplant, pak choi, cherry tomato, and for avocado and choko (Fig. 7.2d), which were sold by the bag (Table 7.3). While the use of plastic packing is likely to extend product shelf-life through a reduction in the rate of dehydration, particularly in leafy crops such as pak choi, that was not specifically assessed in this study.

To validate postharvest loss, a wider survey of vendor postharvest loss of all the commercial fruit and vegetable markets in Samoa (Upolu and Savai'i Islands) is reported in Table 7.4. The Taufusi private market had significantly lower levels of loss (10%) compared to the Afega village market (17%) and Salelologa market (20%). There was no significant difference in the level of postharvest loss between any of the three urban markets located in the Apia region; Taufusi (10%), Vaitele (12.6%) or the Fugalei central markets (13.25%). The Salelologa market (on Savai'i Island), the only market not located on Upolu island, had significantly higher levels of postharvest loss compared to all other markets, with the exception of the Afega village market.

Fig. 7.6 Types of postharvest transport logistics used by Samoan farmers. **a** Community buses used by smallholder-farmers located in the more remote parts of Upolu Island **b** and **c** utility vehicles and cars prevalent in supply chains sourcing produce from farms near Apia and Alesia **d** loose (no packaging used) transportation tends to be limited to supply chains based on heavy product such as cabbage and watermelon, or in larger scale commercial farms directly supplying local retail shops

Comparing the two assessment methods, vendor perception of postharvest loss at the Fugalei market was slightly higher (13.3%) (Table 7.4) than loss determined by direct weighing (6.2%) (Table 7.1). Across all markets, vendors consistently identified banana, papaya and avocado as the most likely crops to incur high levels of postharvest loss. While this was consistent with high levels of postharvest loss quantified in papaya (26.4%), we found relatively low levels of postharvest loss in banana (2.0%), and moderate loss in avocado (6.7%).

The proportion of commercial market vendors to farmer-traders in each market is presented in Table 7.4. On Upolu Island, markets that were dominated by farmer-traders, such as the Afega village and Saleimona roadside markets, tended to have higher levels of postharvest loss. This was not the case for the Salelologa market (on Savai'i Island), which had both high postharvest loss and high commercial vendor representation.

Table 7.4 Postharvest loss in all of the fruit and vegetable markets on the Islands of Upolu and Savai'i, Samoa, based on a survey of vendor recall

Fruit and vegetable market[a]	Postharvest loss (%)	High postharvest loss crops	Type of trader in each market	
			Vendors %	Farmer traders %
Taufusi private market	10a	Banana, papaya, avocado	100	0
Vaitele municipal market	12.6ab	Papaya, banana, soursop	11	89
Fugalei municipal market[b]	13.3abc	Banana, papaya, breadfruit	74	26
Afega village market	17.0bcd	Banana, avocado, pineapple	0	100
Saleimona roadside market[c]	17.5	Banana	0	100
Salelologa municipal market	20.0df	Banana, papaya, tomato	100	0
All markets	12.5		42	58

Notes Total of 67 vendor and farmer-traders across all assessed markets
[a]Mean values followed by different letters are significantly different at $P < 0.05$
[b]Fugalei municipal market is the main fruit and vegetable market for Samoa
[c]Not included in statistical analysis as this roadside market only had two traders

7.4 Discussion

Postharvest horticultural loss in the Fugalei central municipal market in Samoa was 6.2%. While there was no significant difference in mean daily postharvest loss between fruit and vegetable crops, more perishable soft-skinned fruits such as soursop and papaya, and leafy and Western vegetables were the most likely to incur elevated levels of postharvest loss (Tables 7.1 and 7.2). High-value crops such as ginger, early-season citrus and cherry tomato, tended to have lower levels of postharvest loss. Surprisingly, banana and pineapples, two crops commonly associated with high levels of postharvest loss (Murthy et al. 2007; Babalola et al. 2009), incurred comparatively little loss.

While poor agronomic and postharvest handling practices obviously play a role in shaping resultant market loss in Samoa, we believe that much of the overall level of postharvest loss observed in the market, as well as crop-specific differential postharvest loss, was due to prolonged storage in municipal markets. Municipal market storage conditions involved product being loosely displayed on benches, covered with thick plastic sheeting overnight to protect against theft (Fig. 7.7), with the excess product often held in large sacks in the full sun. Intuitively, given that such handling practices also included the product held for up to 7 days under high tropical ambient storage temperatures of up to 32 °C, it is logical to assume elevated levels of postharvest losses. When crops were segregated according to high or low postharvest

Fig. 7.7 Overnight storage of product at the Fugalei municipal market. Produce is covered using sheets and sometimes further secured with netting

vest loss, we found a significant and high correlation between the mean observed postharvest loss in the market and the length of time that the product was held in the market. In crops with low levels of postharvest loss this relationship was linear, with the level of postharvest losses increasing daily. In crops associated with high levels of postharvest losses, these losses occurred rapidly, increasing after 3 days of storage.

Interestingly, based on observations during the market loss assessments, there was very little evidence of anticipated vendors practices to reduce postharvest losses, such as price discounting, or processing, or in-market consumption. Such practices tended to be limited to a small cohort of the more professional market vendors in the Taufusi and Fugalei markets, or by vendors selling commodities such as cabbage that required progressive leaf trimming. Instead, vendors tended to seek to minimise loss by limiting the volume of product sold, only selling highly perishable crops (such as watercress and rambutan) on high-volume throughput days such as Saturdays, or not selling the more perishable crops. This latter point possibly explains the notable disparity between the high postharvest loss in soursop based on direct weighing (Table 7.1), whereas when surveyed very few vendors indicated a concern with this crop in terms of associated losses (Table 7.4).

The importance of market storage on postharvest loss is further highlighted in a comparative study of losses in the Fiji central municipal market (Underhill and Kumar 2014). On the basis of mean daily postharvest loss per crop, there is little difference in the level of loss between horticultural crops in the Fugalei municipal market to that of the Fiji central municipal market (Underhill and Kumar 2014). What is notably divergent is the period of time in which the crops are held in the market prior to sale. In the central municipal market in Fiji, produce tends to be sold within 1–2 days (Underhill and Kumar 2014), which is in direct contrast to the prolonged length of storage at the Fugalei market in Samoa. When market storage is taken into consideration, resultant postharvest loss in the Fugalei market is more than double that seen in the Fiji municipal market. Prolonged market storage in the Fugalei is further highlighted in a recent study of vendor practice in the Honiara municipal market, Solomon Islands. Georgeou et al. (2018) reported that more than 90% of all fruits and leafy vegetables were sold within ½–1 day of arriving at the market.

It is difficult to draw meaningful comparisons from studies in other lesser developed transient countries located outside of the South Pacific region, given significant differences in supply chain logistics and market dynamics. While elevated loss at the wholesale/retail market end of the value chain, and adverse impact associated with prolonged market storage have been well documented elsewhere (Idah et al. 2007; Berinyuy and Fontem 2011; Msogoya and Kimaro 2011), specific levels of crop loss are highly variable (Prabakar et al. 2005; Msogoya and Kimaro 2011).

Protracted municipal market storage is often symptomatic of supply exceeding demand. In the Pacific, this is normally associated with short-term and high-volume supply of seasonal crops, and as such is transient and crop specific in nature. This did not appear to be the case in the Fugalei market during the three sampling periods. Most market vendors only had very small quantities of product for sale, coupled with low overall vendor occupancy at the markets (around 50% of the available vendor stalls at the Fugalei markets were not used). Observations during numerous subsequent visits to the market noted limited consumer presence and purchasing, especially during the early part of the week. This would imply that prolonged market storage might be more a result of consistent and low intensity of consumer demand, rather than short-term elevated product supply. The disconnect between supply and demand in the Fugalei market leading to high levels of postharvest loss in some crops, may be due to limited consumer purchasing of fruits and vegetables, reflecting wider NCD-food dietary trends in Samoa, based on elevated consumption rates of highly processed and energy-dense imported food products. In late 2017, the Vaitele municipal market was permanently closed, the Afega village market partially sold, and numerous retail shops now collectively occupy approximately 30% of the Fugalei municipal market.

Transport logistics are not considered to have a major effect on overall postharvest loss in the Fugalei municipal market. Much of the horticultural production on the island of Upolu is grown within 15 km of the market, and even accounting for remote horticultural production centres, transport logistics were rarely more than 50 km. Supporting this view is the apparent lack of physical injuries to the produce, often symptomatic of in-transit damage observed during postharvest loss assessments. Contrary to horticultural postharvest supply chains in Fiji (Underhill 2013), Papua New Guinea (Chang and Spriggs 2007) or Southeast Asia (Weinberger et al. 2008), Samoan fruit and vegetable supply chains commonly involve product transported in small quantities on comparatively well-maintained sealed roads, with consignment-overloading rarely observed (Underhill 2017). However, we cannot totally exclude transport as a possible contributor simply on the basis of short transport distance. Traditional root crops such as taro were commonly sourced from the more remote villages where there was limited access to commercial transport, necessitating a greater reliance on local commuter buses. This often had the flow-on effect of farmers needing to harvest the previous day and then store product overnight on-farm or on the roadside awaiting bus transport the following morning. While transport distance might be relatively short, future work is required to examine the possible importance of the mode of transport, particularly in the more perishable crops and more remote production source locations.

The importance of product packaging on the level of observed postharvest loss observed in the Fugalei market is unclear. Compared to other Pacific horticultural markets, there was a greater tendency to use plastic bags and packaging in Samoan horticultural markets. While the postharvest benefits of plastic packaging have been well reported (Barmore 1987), given prolonged and high ambient storage temperatures and negligible postharvest disease control, such benefits might be quickly negated through the possible elevated incidence of diseases. During the postharvest loss assessment, there was no consistent evidence of reduced losses associated with the use of plastic packaging. The use of plastic bags by vendors appeared to be more for bulk packaging rather than any purposeful effort to remediate against postharvest loss. As the product is sold by volume and number, and not by weight in Samoan markets, there was also no indirect economic benefit associated with plastic packaging.

In this study, we also sought to determine vendor perceptions of postharvest loss, in the Fugalei central market, as well as all of the other fruit and vegetable markets (municipal, village and roadside markets) on the main island of Upolu and the adjacent island of Savai'i. The perceived level of postharvest loss based in the Fugalei municipal market was higher (13.3%), than when losses were measured through direct weighing (6.3%). The reason for this disparity is unclear, and may simply reflect that vendors believe the postharvest losses are worse than they actually are, or that vendor perception of loss is inclusive of additional economic considerations such as possible price discounting, re-sorting and grading and/or disposal costs. As the vendor survey included both commercial vendors and transient farmer-traders, whereas direct weighing determination was limited to commercial market vendors who regularly participated in the market, there is also the possibility of differential loss between vendor cohorts. This would imply slightly higher postharvest losses incurred by farmer-traders compared to the more professional commercial market vendors. This is consistent with the observation that the markets dominated by farmer traders had higher levels of postharvest loss, at least on the main island of Upolu (Table 7.4). While this was not the case in Savai'i, the Salelologa municipal market on Savai'i was atypical in that commercial vendors primarily sold general household products, with fresh fruit and vegetables as minor-traded items. The fact that vendors identified breadfruit as a crop vulnerable to high postharvest loss is also important (Table 7.4). In the quantification (by weight) of actual postharvest losses, none of the commercial vendors sold breadfruit. This observation not only supports the view that sampling method is likely to account for differences in postharvest loss between the two assessment methods, but also raises the issue of some disparity as to the type of crops being sold by commercial vendors verses farmer-traders.

Postharvest loss in the other fruit and vegetable markets in Samoa was between 10 and 17.5% (Upolu) and 20% on the island of Savai'i. On the island of Upolu, all the markets were located either in Apia (the Taufusi market is only 240 m away from the Fugalei market) or in close proximity to the key production centres. With markets in close proximity to each other and short farm-to-market transport distance, differences in market loss are unlikely to be due to geographic propinquity. On the island of Savai'i, there was a limited supply of fresh fruits and vegetables, with the product either imported or sourced from Savai'i with limited evidence of inter-island supply chains observed at the time of sampling.

While not quantified, there was a notable observational difference in the level of consumer activity between the markets, with the private Taufusi market considerably busier than all of the other markets assessed. This is interesting given the Taufusi market had significantly lower postharvest losses compared to the Afega village, the Saleimona roadside markets, and the Salelologa market. This is consistent with the view that lower consumer demand may be contributing to extended market storage, and higher resultant postharvest loss. Further work is needed to examine and verify the possible importance of consumer purchasing behaviour as a possible contributor to postharvest loss in fruit and vegetable markets in Samoa.

7.5 Conclusions

Mean postharvest loss in the main Fugalei municipal fruit and vegetable market in Samoa was considered to be comparatively high relative to similar municipal markets in Fiji. While poor agronomic and postharvest handling practices no doubt influence such levels of postharvest horticultural loss, extended market storage involving high tropical ambient temperatures was of critical importance. There was some evidence that prolonged market storage may be due to low consumer demand, but more work is required to validate this conclusion. Given differences in the level of postharvest loss between the various fruit and vegetable markets in Samoa, further work is also needed to explore the potential influence of vendor practice, market design, market location and operations, and purchasing patterns, to examine their collective impact on food security.

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Conflict of Interest The authors declare that they have no conflict of interest.

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Chapter 8
Can the Tropical Western and Central Pacific Tuna Purse Seine Fishery Contribute to Pacific Island Population Food Security?

Graham M. Pilling, Shelton J. Harley, Simon Nicol, Peter Williams and John Hampton

Abstract Projected population growth in Pacific Island countries, combined with their narrow resource base, declines in net food production per capita and growing reliance on imported foods will increase food insecurity. We examined whether policies requiring retention of edible, non-target catches by the Western and Central Pacific purse seine fishery could aid food security in seven Pacific Island countries. Estimated catches within respective exclusive economic zones imply average annual per capita protein benefits from 270 g in Papua New Guinea to 25 kg in Tuvalu. Stability of supply is affected by annual catch fluctuations; the two countries with greatest potential per capita protein gains, Nauru and Tuvalu, experience a 50 and 20% reduction in supply, respectively, in poor years. Access to benefits is affected by practicalities of landing port location, food distribution networks and communication links, particularly for countries comprised of many islands. Only five of seven countries, which exclude the two with greatest potential per capita benefit, have significant tuna landings directly into their ports. Specific policy mechanisms may be required to increase non-target catch access. While marine resources have a

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significant part to play in improving food security, use of non-target catch will not solve food insecurity alone. The tradeoffs between maximising economic benefits from licensing industrial tuna purse seine fishing versus the potential of the resource for consumptive use, and the potential social impacts that may result, are critical national and regional policy issues facing Pacific Island countries.

Keywords Pacific Islands · Purse seine · Catch retention · Food security · Fishery policy

8.1 Introduction

Most Pacific Island countries and territories (PICTs) have a narrow resource base, with limited land for agriculture and grazing, often poor soil, and crops that are being increasingly affected by extreme climatic events such as typhoons and droughts. In turn, the risk of atoll soil salination due to sea level rise and severe weather events is increasing (FAO 2008; Hanich et al. 2018). Common agricultural protein sources such as rice or wheat are therefore difficult to grow in significant volumes for many islands. While the larger volcanic islands of Papua New Guinea (PNG) and Solomon Islands have greater potential, and subsistence-level agriculture is common, overall net food production per capita has declined in all countries since the early 1990s, except Kiribati and Samoa, while dependency on imported foods has increased (SPC and CSIRO 2011). In contrast, livestock production has generally increased around the Pacific region since the 1960s, especially poultry and egg production (SPC and CSIRO 2011). However, large-scale farming of cattle and pigs is primarily found in Melanesia and the larger Polynesian countries. The potential to increase this production further is hampered by limited space, competition for water supplies, and the need for feed protein within the land-based livestock sector.

Overall reductions in local food production and an increasing preference for imported and processed foods such as canned fish, corned beef or frozen chicken within PICTs has led to negative food trade balances, exacerbated by the increase in global oil prices that affect the cost of both local food production and the transport of imported food (SPC and CSIRO 2011). This adds further pressures on national economies while having implications for nutrition and health (Hughes and Lawrence 2005); islanders are at increased risk of chronic diseases such as type 2 diabetes, hypertension, anemia and goitre (Cheng 2010; WHO 2010; Charlton et al. 2016). The growing potential for chronic PICT food insecurity has led to an increasing policy focus on ensuring the availability and stability of food supply, combined with sufficient access to it and the ability to utilise it (FAO 1996, 2002; WHO 2010).

A positive note for PICT food security is the abundance of natural marine resources within their waters. These are already seen as important to the food security, health and livelihoods of PICT populations and offer significant national- and household-level incomes and employment (Bell et al. 2009, 2013a; Gillett and Cartwright 2010; Gillett 2016). However, the particular importance of these natural resources often goes unrecognised within analyses at a global scale (Dulvy and Allison 2009). Globally, fish provide 17–20% of the animal protein to 3.2 billion people, and higher shares of diets in developing countries (FAO 2018), as well as supplying essential fatty acids, vitamins and minerals such as iodine. The contribution of marine resources to the diet of Pacific Islanders is more than 3–4 times the average global per capita fish consumption, representing 50–94% of animal protein in the diet of coastal and urban communities, and is currently sourced primarily from inshore (e.g. reef) subsistence and artisanal fisheries, particularly in rural areas (Bell et al. 2009, 2013a). However, increasing human population sizes will place further pressure on nearshore marine renewable resources (Williams 1996; Bell et al. 2015) with increased exploitation pressure and reduced resource health (e.g. Newton et al. 2007). This, and predicted negative impacts of future climate change on coastal fisheries, will create a widening gap between increased PICT population protein requirements and decreased inshore protein supply (Bell et al. 2013b). As a result, regional policy interest has focused on the utility of offshore fish resources for food security (SPC 2013; Wabnitz et al. 2018).

A key component of oceanic fisheries in the Western and Central Pacific Ocean (the Pacific Ocean west of 150°W) is the purse seine fishery, which operates primarily in tropical waters. In 2017, the total purse seine fishery caught around 1.8 million mt (metric tonnes) of skipjack, yellowfin and bigeye tuna (Williams and Reid 2018), representing around 55% of the global tuna catch. While vessels involved in these fisheries are increasingly reflagging to Pacific Island countries, they are primarily distant water fishing vessels from China, Japan, Korea, Taiwan, and the United States, licensed to operate within the Exclusive Economic Zones (EEZs) of PICTs. Licensing vessels to fish within their EEZs provides a considerable and increasing proportion of government revenue in many Pacific Island countries, representing over 10–75% of annual revenue (Bell et al. 2013a; Gillett 2016).

Since their establishment in 1982, the Parties to the Nauru Agreement (PNA) have exerted increasing management influence on the purse seine fishery in the WCPO. The EEZs of these eight countries (the Federated States of Micronesia (FSM), Kiribati, Republic of the Marshall Islands, Nauru, Palau, PNG, Solomon Islands and Tuvalu) represent key areas for tropical tuna purse seine fishing. Following the introduction of vessel access arrangements, 75–90% of the fishing effort of purse seiners in the tropical WCPO has been within PNA waters (WCPFC [Western and Central Pacific Fisheries Commission] and SPC 2018).

Purse seine operations do not result in a 'clean' catch of target tuna species alone (Peatman et al. 2018a). Non-target species are caught that may either be retained for sale if it is of sufficient value, consumed on board the vessel by the crew or retained to take home, or discarded overboard. Tuna schools around which purse seine vessels set their net fall into two main categories: first, tuna schools associated within floating objects, which includes logs and man-made fish aggregating devices (FADs); second, those not associated with floating objects. We refer to the first type as 'FAD sets' and the second as 'free school sets'. The nature and extent of non-target catch differs between these set types (e.g. Romanov 2002; Brouwer et al. 2018), as well as with the geographical location of fishing (e.g. Lawson 2011).

Non-target ‘edible’ species catches within the purse seine fishery have been a focus of increasing policy interest as a previously untapped resource to combat food insecurity (e.g. WCPFC 2017). However, the levels of this non-target catch, the stability of its supply, and the ability of PICTs to access and utilise it for increased food security have not been examined. Here, we examine the level of specific non-target edible finfish catches from the tropical WCPO purse seine fishery over the period 2000–2010 to identify the potential availability and stability of this previously untapped resource for Island food security, specifically in terms of supporting growing national protein requirements in the face of challenges in other food supply sectors. We also investigate the current geographical distribution of tropical purse seine catch landings to examine the practicalities involved in accessing the potential food security benefits by some of the most vulnerable populations on earth.

8.2 Materials and Methods

8.2.1 Data

Three sources of data were examined: fishery observer information; purse seine regional vessel logsheet information; and census-based population estimates. The analysis concentrated on observations from fishing operations in the EEZs of seven of the PNA members: FSM, Kiribati, Republic of the Marshall Islands, Nauru, PNG, Solomon Islands and Tuvalu (Fig. 8.1).

Records from Fishery Observer Programmes held by The Pacific Community (SPC) provide the most comprehensive data set available on the level of non-

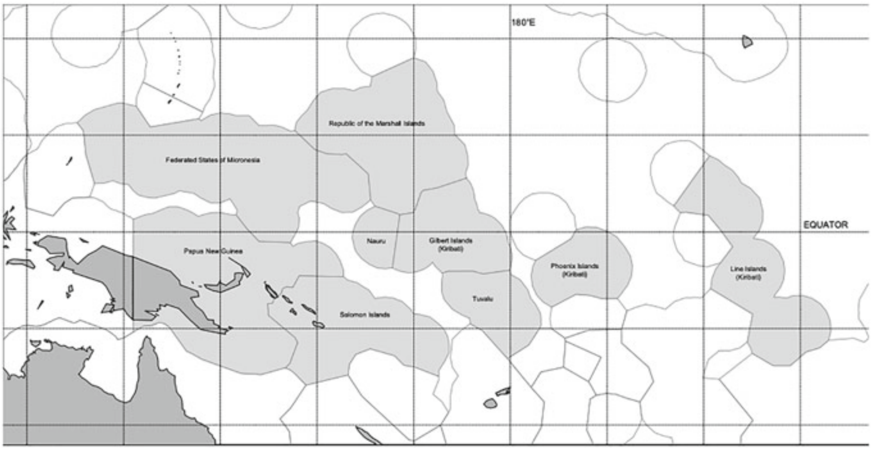

Fig. 8.1 National exclusive economic zones from which observer and logsheet data were analysed

target species caught by purse seiners. Observer coverage of purse seine activity has increased over time, particularly following the requirement for 100% observer coverage through WCPFC Conservation and Management Measures from 2010. Nevertheless, observer data represent a subset of regional total purse seine activity (coverage increasing from 5 to 10% of trips prior to 2009 to 80–90% coverage in recent years). Set by set observer data on individual species' occurrence and catch levels were collated across the WCPO from 20°N to 20°S, by EEZ. These data were used to estimate non-target species catch rates, for the period from 2000 to 2010 inclusive.

Data were analysed for specific species and species groups, guided by recent discussions on potential catch retention requirements (WCPFC 2017). In addition to the combined catch of the three main tunas (skipjack (*Katsuwonus pelamis*), yellowfin (*Thunnus albacares*) and bigeye (*T. obesus*) tuna, grouped into a total tuna category), eight key non-tuna edible finfish species were examined (Table 8.1), representing the most common 'edible' species observed in purse seine catches in the WCPO. Billfish species—black marlin, blue marlin, striped marlin and sailfish—were combined into a total billfish category.

Purse seine regional vessel logsheets provide information on fishing effort. Total annual effort (number of sets) by set type ('FAD' or 'free school') was calculated from logsheet information. As logsheet returns cover a high proportion of fishing, but not all (over 85% of activity; Williams 2012, 2018), effort was raised to represent the total purse seine fishing activity in each of the EEZs. While catch weight of non-target species is also available from logsheets, these data are expected to be less complete than that obtained through observers.

Purse seine regional vessel logsheets also provide information on the port in which tuna catches from each vessel's trip were landed. The port of landing was identified on logsheets for 91% of records. This information provided a reasonable indication of the destination of potential non-target catch landings.

Population census estimates for each country were available through SPC's Statistics for Development population census programmes (http://www.spc.int/sdp/). These provide the most recent estimates of total population, from which potential current demand for protein can be estimated.

8.2.2 Catch Rates

The geographical location of fishing events is expected to be an important factor determining catches given known influences of environmental and oceanographic features on catch rates and pattern of fishing activity. Estimates were therefore calculated by EEZ.

In a high proportion of sets (see Table 8.1), no catch of a species under consideration was recorded ('zero catch' sets). To take this into account, a delta-lognormal Generalized Linear Model (GLM) approach was taken, where presence/absence in a

Table 8.1 Finfish species examined, and the proportion of 'positive catch' sets and mean catch rates (kg/set, for non-target species) by species and set type across the period 2008–2010 and areas of the tropical WCPO shown in Fig. 8.1. Total represents combined estimates for non-tuna species (excluding the combined billfish species group)

Common name	Scientific name	Proportion of observed sets with positive catch		Catch rate (kg/set)	
		FAD sets	Free school sets	FAD sets	Free school sets
Total tuna		0.81	0.40	40.1[a]	21.1[a]
Total billfish		0.11	0.07	20.5	13.0
Black marlin	*Istiompax indica*	0.03	0.02	5.8	3.3
Blue marlin	*Makaira nigricans*	0.06	0.04	11.6	6.9
Striped marlin	*Kajikia audax*	0.01	0.01	2.0	1.2
Sailfish	*Istiophorus platypterus*	0.01	0.00	0.4	0.3
Barracudas	*Sphyraena spp.*	0.07	0.01	2.1	0.2
Dolphinfish	*Coryphaena hippurus*	0.15	0.05	66.0	2.0
Rainbow runner	*Elagatis bipinnulata*	0.37	0.09	169.3	3.2
Wahoo	*Acanthocybium solandri*	0.09	0.02	7.5	0.3
Total non-tuna				264.7	17.3

[a]Total tuna catch rate in mt/set

set was treated separately, and non-zero catch rates were modelled using a lognormal distribution (Lo et al. 1992), and fitted to the data using the R-software (R Core Team 2012).

For presence/absence, set by set data for each species were re-coded into binary format. The proportion of sets where a species was present in the catch (positive sets) was modelled using the logit function as the link between the linear factor component and a binomial error distribution:

$$\text{Species\_present}_{i,j,k} \sim \text{Year}_i * \text{Set\_type}_j * \text{location}_k \tag{8.1}$$

where $i = 2000 - 2010$, $j =$ FAD or free school set and $k =$ the geographic location (EEZ).

The catch rate (kg per set) in sets where a species was caught (positive sets) was modelled assuming that the error followed a lognormal distribution:

$$\text{Ln(Species\_cpue)}_{i,j,k} \sim \text{Year}_i * \text{Set\_type}_j * \text{location}_k \tag{8.2}$$

where $i = 2000 - 2010$, $j =$ FAD or free school set and $k =$ the geographic location (EEZ).

A natural log transformation was sufficient to achieve normality of catch rate data in the majority of species' models. For the model of total tuna catch rate, the Box–Cox procedure was applied to improve normality of the log-transformed data (Box and Cox 1964); a constant of 2.15 was first added to the untransformed values. For dolphinfish and rainbow runner CPUE models, a $\log_{10}$ transformation was most appropriate.

For each species and both model components, the most complex initial model examined contained the three-way interaction between year, set type and location. The 'best'—generally more simple—model for each was selected on the basis of the Akaike information criterion (AIC) value and model parsimony, and through examination of residual patterns and linearity of the quantile-quantile plot (positive CPUE value models only). Based on the models for each species, an average catch rate by year, set type and location was estimated from the product of the two model predictions, with appropriate bias correction applied to the lognormal estimates.

8.2.3 Total Catch Levels

Raised annual effort (number of sets) by set type was estimated from logsheet information for the period 2000–2010 in the relevant EEZs (Fig. 8.1). Predicted species' average catch rates by year, set type and location from the GLMs were multiplied by the corresponding number of sets (effort) to estimate annual species catches. 95% confidence intervals around the mean catch were estimated using Cox's method (Fletcher 2008).

8.2.4 Contribution to Food Security

To examine the availability of local (EEZ-based) non-target species catch as a source of protein for local consumption, recent (2008–2010) mean total non-target catch estimate for each EEZ were divided by the most recent SPC population census information for each country. To examine the stability of potential supply, the inter-annual variability of the time series of estimates were examined and compared to the long-term mean per capita values.

The accessibility of the non-target catch was also examined at a national scale. Using logsheet information on each vessel's destination port, and effort from the seven EEZs, we estimated the non-target catches by unloading port for the recent period (2008–2010). Destination ports were grouped into four categories: 'distant water fishing nation'; 'Pacific Island country or territory with onshore processing facilities' or 'Pacific Island country or territory without onshore processing facilities', based upon the information provided within Hamilton et al. (2011); and 'unknown', where no destination port information was entered.

8.3 Results

8.3.1 *Catch Rates*

Observer data were available for 69,563 sets undertaken during 2000–2010. For a number of species (striped marlin and sailfish in particular), there were limited catch events across the data set (Table 8.1), and hence estimates were less precise. The general structure of the species-specific GLM models developed from the data, and related statistics, are presented in Table 8.2.

A higher proportion of FAD sets succeeded in catching fish compared to free school sets, for all species. Over the period 2008–2010, 81% of FAD sets resulted in a tuna catch, compared to 40% of sets on free school tuna (Table 8.1). The most common non-target species were rainbow runner (noted in 37% of FAD sets) and dolphinfish (in 15% of FAD sets), while the incidence of other species was noted in less than 10% of FAD sets. For free school sets, the frequency of occurrence was less than 10% of sets for each species.

To illustrate the relative pattern of catch levels by set type, mean catch rates for each species were calculated by set type across EEZs and years over the period 2008–2010 inclusive (Table 8.1). All species had a higher catch rate in FAD sets. For total tuna, the average catch in FAD sets (around 40 mt/set) was almost twice that from free school sets (21 mt/set). Combined non-tuna species average catch rates (in kg/set) were over fifteen times greater in FAD sets than free school sets; on average 265 kg of the species examined here were caught in each FAD set, compared to 17 kg in a free school set. Rainbow runner and dolphinfish were the most common non-target species by weight in FAD sets with average catch rates of 169 kg/set and 66 kg/set in recent years, respectively. In free school sets blue marlin was the most common species by weight, with a catch rate of 7 kg/set, followed by black marlin and rainbow runner (3 kg/set).

8.3.2 *Effort Data*

Raised total annual effort by set type showed a general increasing trend in the total number of purse seine sets made in the EEZs examined since 2000. Number of sets increased from 21,473 sets in 2000 to 49,528 sets in 2010 (Fig. 8.2). The proportion

Table 8.2 Delta-lognormal GLM structures and ANOVA statistics, as used to estimate species-specific catch rates (mt/set)

Species	Model	*P* value where variable significant (ANOVA)						Resid. Dev	Df
		Year	School	EEZ	Year * School	Year * EEZ	School * EEZ		
Total tuna	Bin.	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	75936	69469
	Ln+2.15	<0.001	0.254	<0.001	<0.001	<0.001	<0.001	47939	42625
Billfish	Bin.	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	42160	69469
	Ln	<0.001	0.739	<0.001	<0.001	–	<0.001	5339	6519
Black marlin	Bin.	<0.001	<0.001	<0.001	–	–	<0.001	18216	69539
	Ln	0.259	0.276	0.116	–	<0.001	0.035	1472	2005
Blue marlin	Bin.	<0.001	<0.001	<0.001	–	<0.001	<0.001	26691	69479
	Ln	0.012	0.201	<0.001	–	–	0.020	2410	3417
Striped marlin	Bin.	<0.001	<0.001	<0.001	–	–	<0.001	8189	69539
	Ln	<0.001	–	–	–	–	–	538	749
Sailfish	Bin.	<0.001	<0.001	<0.001	–	–	–	61465	69545
	Ln	–	–	<0.001	–	–	–	443	530
Barracudas	Bin.	<0.001	<0.001	<0.001	–	<0.001	<0.001	24213	69479
	Ln	0.014	<0.001	<0.001	0.001	<0.001	<0.001	3788	3853
Dolphinfish	Bin.	<0.001	<0.001	<0.001	–	<0.001	<0.001	37502	69479
	Log_{10}	<0.001	<0.001	<0.001	<0.001	<0.001	–	2958	8054
Rainbow runner	Bin.	<0.001	<0.001	<0.001	–	<0.001	<0.001	44674	69479
	Log_{10}	<0.001	<0.001	<0.001	<0.001	<0.001	–	8554	18241
Wahoo	Bin.	<0.001	<0.001	<0.001	–	<0.001	<0.001	26250	69479
	Ln	<0.001	–	<0.001	–	<0.001	–	5554	4536

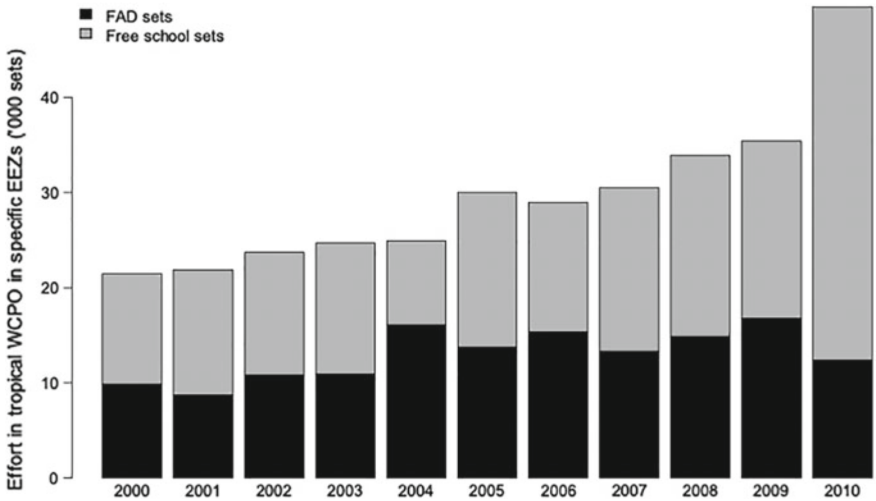

Fig. 8.2 Level of effort (sets) by year and set type in the EEZs examined

of FAD and free school sets per year was comparable, with 40–60% of sets being one type or the other. An exception was 2010, where the fishery showed a significantly greater proportion of sets on free schools (75%), commensurate with a different fishing pattern around a 3-month FAD-fishing closure in that year, while in 2004 there was a greater proportion (65%) of FAD sets.

8.3.3 Total Catch Levels

Estimated annual catches for each species and species group (all set types combined) are presented in Table 8.3. The time series of annual catch levels (including estimated uncertainty) by species and set type is presented in Fig. 8.3. To place total non-target species catch estimates in context, combined catches represent less than 0.75% of total tuna catch estimates. Free school catches were estimated to contain a non-target catch component of <0.2% of the total catch, while in FAD sets this catch was <1% of the total. Greatest total mean estimated catch of combined non-tuna species examined was in 2004 at 5,675 mt, coinciding with peaks in the estimated catch of rainbow runner (around 67% of the total non-target catch; Table 8.3) and dolphinfish. Taking into account the variability in CPUE estimates, the 95% confidence intervals indicated that the total catch of non-tuna species was between 5,438 and 5,931 mt in that year.

Following the pattern seen in catch rates, total annual tuna catches were generally higher from FAD sets compared to that from free school sets. This pattern was, however, reversed in 2010 (Fig. 8.3).

Table 8.3 Estimated mean total catches (mt) for each species or species group by year across the EEZs examined. Total represents the estimated weight of non-tuna species (excluding the combined billfish species group)

	Total tuna	Billfish	Black marlin	Blue marlin	Striped marlin	Sailfish	Barracudas	Dolphinfish	Rainbow runner	Wahoo	Total (non-tuna)
2000	6,06,414	173	69	72	20	5	23	362	1168	88	1,806
2001	6,07,464	272	135	113	10	11	27	296	1544	82	2,218
2002	6,80,737	315	114	166	18	10	25	662	1896	55	2,946
2003	6,80,986	450	198	175	55	16	26	766	1736	49	3,020
2004	7,64,495	510	194	255	39	19	35	1227	3789	117	5,675
2005	7,59,721	450	138	250	30	19	46	854	2960	63	4,358
2006	8,17,642	547	180	305	49	17	34	1070	3646	50	5,351
2007	9,83,623	546	156	335	44	11	30	625	2747	51	3,999
2008	10,33,875	474	138	288	34	16	48	836	2564	83	4,007
2009	8,76,106	461	115	267	49	8	39	775	2023	79	3,355
2010	11,21,480	563	169	302	65	16	16	702	2226	44	3,540
Average	8,12,049	433	146	230	37	13	32	743	2391	69	3,661

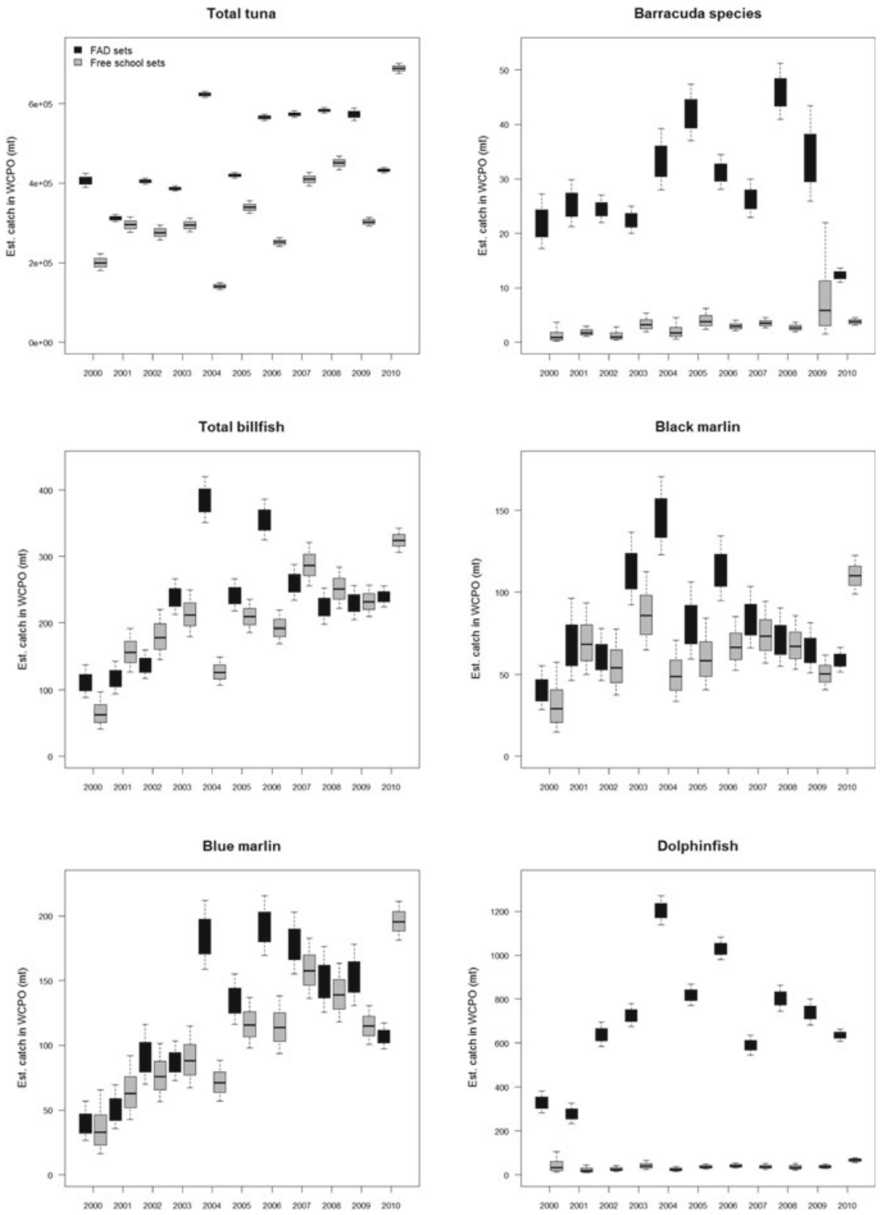

Fig. 8.3 Total catch of each species and species group (mt) by year and set type for the period 2000–2010. Whiskers represent the 95% confidence interval range of the mean catch estimate of each species (extreme values therefore not presented). Note the different scales on the y-axis of each graph

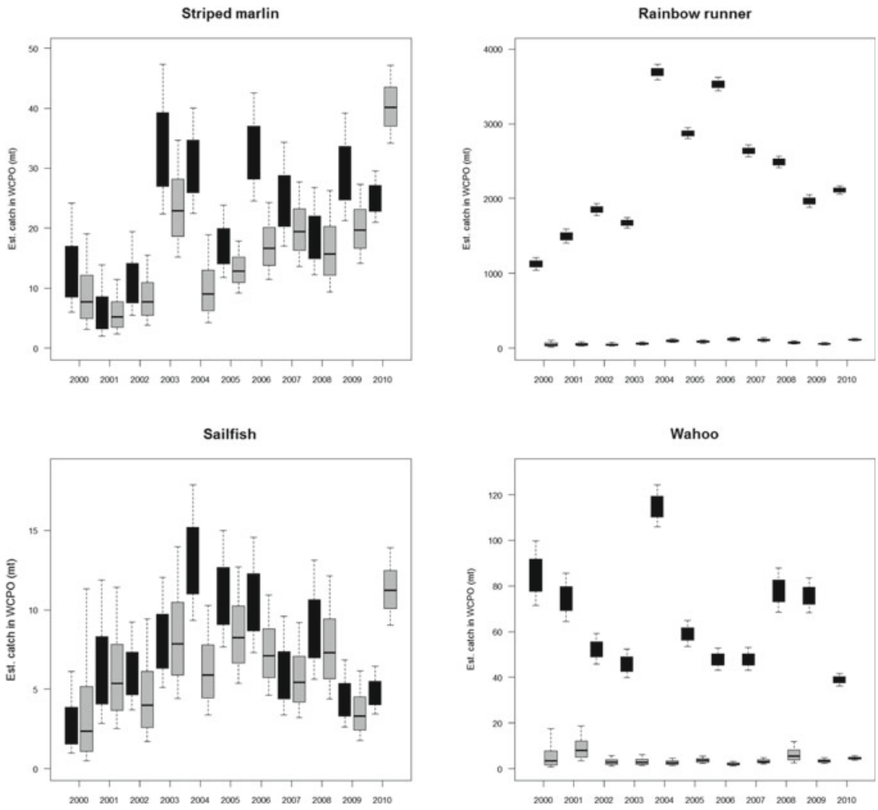

Fig. 8.3 (continued)

Estimated non-billfish catches were higher in FAD sets compared to free school sets. Highest non-target catch levels were estimated for rainbow runner, with catches peaking in the FAD set component at around 3,690 mt in 2004, and remaining above 2,500 mt until 2009. For dolphinfish, the next most common non-target species, the highest catch level was also estimated to be in FAD sets in 2004 at around 1,200 mt, and catch estimates from FAD sets remained over 550 mt between 2002 and 2010. Catch levels in free school sets for both species were an order of magnitude lower (below 120 mt and 70 mt respectively). For other non-billfish species, estimated mean catches combined across set types were below 50 and 120 mt per year, respectively.

The pattern in total billfish catches over time varied between set types, but was generally higher in FAD sets (a combination of higher catch frequency and catch rates) before 2007, and subsequently higher in free school sets. FAD set catches peaked in 2004, declined to around 250 mt and then remained stable through to 2010, while free school set catches increased to a peak in 2007 at 290 mt, peaking again in 2010. Combined, mean catch estimates were greatest in 2010 at 563 mt (Table 8.3). Total billfish catch patterns were primarily driven by blue marlin catches, and to a lesser extent those of black marlin. Annual catches of other billfish species (striped marlin, sailfish) were estimated to be below 70 mt and 20 mt, respectively.

8.3.4 Contribution to Food Security

To examine the potential contribution of estimated purse seine bycatch to PICT food security, the average per capita population protein supply arising from the local (EEZ) non-target species catch are presented in Table 8.4. Based on 2008–2010 average catches, a potential benefit of from 270 g (PNG) to 25 kg (Tuvalu) per person per annum could be gained from landing non-target species catch caught in each country's EEZ into local ports. For comparison, the estimated increased national requirement for protein based on desirable minimum levels of protein consumption (35 kg/year) or recent consumption rates if higher (FSM, Kiribati, Nauru) combined with predicted population increases over the period to the year 2035 are detailed in Table 8.4. Additional protein demands of between 790 mt (Nauru) and 141,000 mt per year (PNG) are estimated by 2035. The potential contribution of previously untapped purse seine non-target catches as a source of protein represent between 1% (PNG, Solomon Islands) and 25% (Nauru) of the future additional protein needs per country.

A further important aspect of the potential for purse seine bycatch to contribute to Island food security is the stability of supply. The estimated variability in annual total non-target species catch levels for each PICT can be large (Table 8.4). Lowest estimated annual bycatch levels for countries could be 809 mt below average levels (PNG), while the biggest per capita impacts from varying annual catch levels are seen in Nauru (a 50% reduction in protein per capita implied by the lowest annual catch estimate) and Tuvalu (a 20% reduction).

National access to potential food security benefits under current fishing practices is evaluated by examining the destination of recent (2008–2010) tuna catches from the seven EEZs as a proxy for the destination of retained non-target catches. Between 0% (Nauru) and 61% (Solomon Islands) of potential estimated total non-target catch within an EEZ also had a destination port noted within that EEZ (Table 8.5). However, only four of those countries have a port with tuna processing facilities (ports to which between 20 and 60% of the total non-target catch was taken). The destination of between 67% and 96% of non-target catches within an EEZ were PICT ports within the WCPO region, which included ports in American Samoa and Fiji (10% and <1% of the estimated potential non-target catch respectively; Fig. 8.4). Landings of fish from EEZs directly into foreign ports (distant water fishing nations, primarily in Japan, Philippines, Korea, China and Taiwan) was significant for estimated non-target catches taken in the EEZs of FSM (19% of catches) and PNG (11%), but was less than or equal to 5% for other EEZs.

Table 8.4 Estimated per capita non-target catch weight by country, estimated additional fish needed for food to meet protein demands by 2035 (from Bell et al. 2011), average non-target species catch over the period 2008–2010, and range of estimated catches over the period 2000–2010 (min-max), and percentage of additional protein requirements that could be met by non-target catches (numbers in parentheses represent the range)

Country	Per capita non-target species catch weight (kg/person)	Additional fish needed for food by 2035 (mt)[a]	Average non-target catch (mt per annum, 2008–2010)	Annual non-target catch range (2000–2010)	% protein shortfall met by non-target catch
Federated States of Micronesia	4.262	7,300	437	169–1,291	6% (2–18%)
Kiribati	9.239	9,000	855	314–1,522	9% (3–17%)
Republic of the Marshall Islands	0.774	2,200	39	21–162	2% (1–7%)
Nauru	21.034	790	194	98–566	25% (12–72%)
Papua New Guinea	0.268	140,700	1,393	584–2,151	1% (0–2%)
Solomon Islands	0.917	33,900	473	36–855	1% (0–4%)
Tuvalu	25.289	1,400	242	49–316	17% (4–23%)

[a]Adapted from Bell et al. (2011)

8.4 Discussion

8.4.1 Catch Rates and Catches

The type of set (FAD or free school) had a significant influence on the occurrence of non-target species, and their catch rates (kg/set). FAD sets had a higher probability of resulting in tuna and non-target catches compared to free school sets. Estimated catch weight of non-target species per set was over fifteen times greater in FAD sets compared to free school sets, consistent with findings in other regions and oceans (e.g. Lawson 1997; Gaertner et al. 2002; Martínez-Rincón et al. 2012). Year and location of fishing (EEZ) and/or interactions between the three variables, also had significant influences, depending on the species (Table 8.2).

Management interventions limiting FAD fishing, designed to reduce fishery impacts on younger (potentially immature) target tuna (e.g. Leroy et al. 2013), can influence the level of non-target species catches, and hence have implications for food security. From the pattern of catches by set type, the recent implementation of a ban on FAD fishing in specific months (e.g. WCPFC 2017) should reduce catches of

Table 8.5 Proportion of 2008–2010 estimated potential non-target catch within specific PICT EEZs whose destination port was noted as the home port (port within that EEZ) or other PICT ports with or without processing facilities, distant water fishing nation (DWFN) ports, or whose delivery port was unknown

	Home port			Other PICT port		Total PICT	DWFN	UNK
	With processing	Without processing	Total	With processing	Without processing			
Federated States of Micronesia	0.00	0.48	0.49	0.26	0.04	0.79	0.19	0.02
Kiribati	0.00	0.25	0.25	0.53	0.11	0.89	0.05	0.06
Republic of the Marshall Islands	0.59	0.00	0.59	0.05	0.30	0.94	0.04	0.02
Nauru	0.00	0.00	0.00	0.45	0.50	0.95	0.04	0.01
Papua New Guinea	0.36	0.00	0.36	0.05	0.26	0.67	0.11	0.22
Solomon Islands	0.21	0.40	0.61	0.23	0.11	0.96	0.02	0.02
Tuvalu	0.00	0.02	0.02	0.68	0.25	0.95	0.01	0.04

rainbow runner and dolphinfish in particular, two key non-target species by weight. However, as seen for the catch estimates of billfish in 2010, increases in the total number of sets, combined with still significant catch rates of species on free school sets, led to peaks in some species' total catch estimates despite FAD closures. The impact of such management measures is therefore species-specific, as found in other purse seine fisheries. Gaertner et al. (2002) estimated over a 50% reduction in marlin catch during a 3-month moratorium on FAD fishing adopted by the European purse seine fishery in the eastern Atlantic Ocean, but a doubling in (by comparison small) sailfish catch levels. Similarly, recent estimates by Peatman et al. (2018a) for the WCPO as a whole indicated higher bycatch estimates for billfish species, driven by greater proportions of free school sets than seen historically. Therefore, while species composition is influenced by management interventions, the potential for the purse seine fishery to contribute to food security remains.

8.4.2 Contribution to Food Security

Increasing pressure on all natural resources due to human population increases and climate impacts and growing population health issues, has highlighted the importance of identifying solutions to PICT food insecurity. We discuss the potential benefits

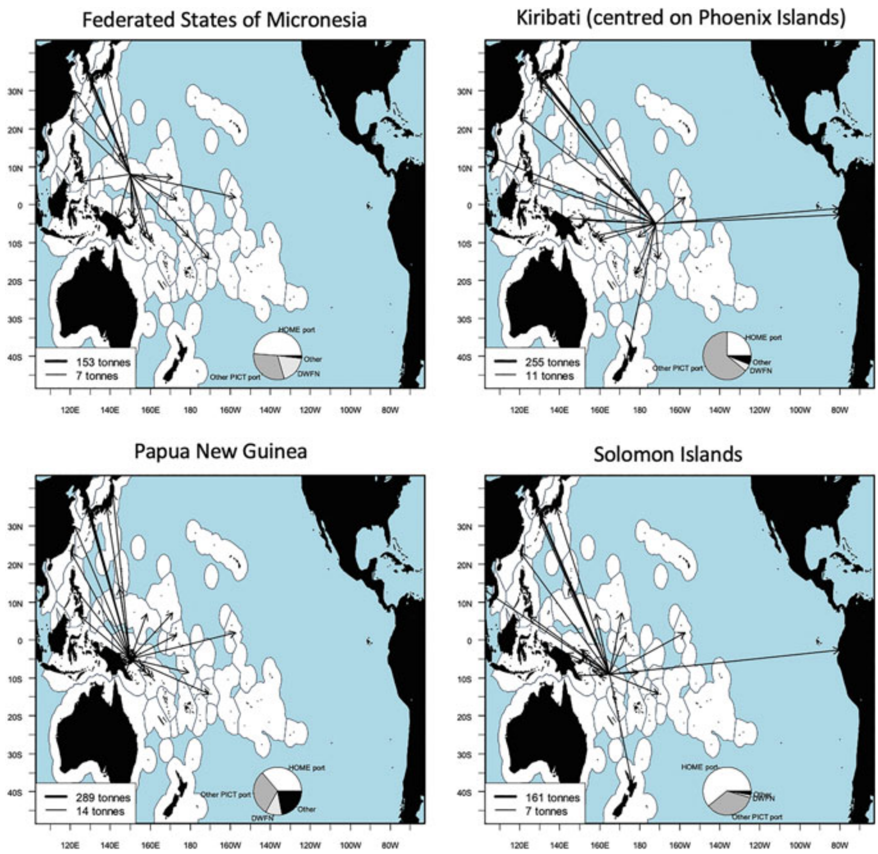

Fig. 8.4 Landing port and quantity of tuna (legend presents the level of tonnage (total 2008–2010) presented by the line thickness). Pie chart presents proportion of total tuna catch delivered to port country groups

of industrial purse seine non-target catches under three of the four main dimensions of food security: availability, stability and access, with a focus on the important supply of natural protein for Pacific Islanders while reducing national reliance on less healthy imported foods.

8.4.2.1 Availability

The potential for catch retention policies to contribute to the availability of PICT food security varied significantly between countries. For those countries with relatively small populations, for example, Nauru and Tuvalu (both with less than 10,000 people) over 20 kg of additional protein from their EEZs would be, on average, available per person, per annum, by landing local non-target species catches (optimistically assuming a 100% conversion rate). These levels are close to the ~24 kg per annum level calculated from World Health Organisation recommendations (0.83 g/kg per day and assuming an 80 kg person; WHO 2002), but below that recommended by SPC's Public Health Programme (35 kg of fish per year; SPC 2008). However, estimated local non-target species catches alone are insufficient to meet either of these levels for the other five countries. In turn, based upon future increased protein requirements resulting from population growth in each country (Bell et al. 2011), recent mean estimated non-target catch levels would be insufficient to meet additional demands in all seven countries (Table 8.4), contributing on average between 1 and 25% of additional estimated demand by 2035 (but up to 72% in good years for Nauru).

8.4.2.2 Stability

To provide food security benefits, the supply of non-target catches needs to be relatively stable over time. However, the analysis indicates significant annual fluctuations in EEZ catch levels. For example, in poor years the two countries with the greatest potential per capita gain in protein (Nauru and Tuvalu) would suffer a 50% and 20% reduction in supply, respectively.

These fluctuations are in part due to the influences of environmental changes such as prevailing El Niño-Southern Oscillation (ENSO) conditions, which strongly influence the regional location of fishing effort (Lehodey et al. 2003). For example under La Niña conditions, where purse seine fishing concentrates in western waters, countries to the east including Tuvalu and Kiribati will have reduced options to benefit from industrial non-target catches. To take this into account, greater reliance on industrial fishery-based protein opportunities will require investment in handling and storage infrastructure to cope with both potentially large quantities of fish arriving in port at any one time during the year, and to buffer against longer term fluctuations. Suitable storage mechanisms (e.g. canning, deep freezing) may be needed, which require considerable investment.

In the longer term, stability of supply will also be influenced by the potential trade-offs for operators involved in requirements for retention of non-target species. Utilising catch for human benefit which might otherwise be discarded dead (observer records suggest between 25 and 80% of the non-target species catch weight may currently be discarded, dependent upon set type and species) is appealing. Enforced retention requirements may, however, provide an incentive for vessel operators to reduce their non-target catches over time, maximising their hold space and hence revenue from more valuable tuna species. That would be detrimental to longer term Island food security.

8.4.2.3 Access

To gain benefits from non-target commercial catches, they need to be landed in-country and made accessible to the population. The actual landing destination of catches from a given EEZ varies significantly. Most critically, the presence of ports in countries with good transport links and processing facilities will influence the benefit a PICT can potentially gain from the retention of non-target species catches. Nauru has highly limited port facilities, while port facilities in Tuvalu are currently not a primary focus for tuna landings (and minimal outside the main island) but it is an increasing purse seine transshipment hub. For these two countries, with the greatest potential to benefit in per capita protein and associated health benefits from locally-caught non-target species, there appear limited opportunities to obtain benefits in the short term.

Over 67% of the estimated non-target species catch had a destination port in a Pacific Island country, including PNG, Kiribati, Marshall Islands, Solomon Islands and FSM. Five of the seven countries examined are therefore in a position to more readily access the benefits from landings of non-target catches under current arrangements. These ports, and others in American Samoa and Fiji, which are outside the general area of purse seine fishing, are also a significant destination for catches taken in EEZs other than those examined in detail here, and hence the per capita protein benefits for these specific countries might be higher than estimated.

Since ports within Pacific islands generally represent key national population centres and distribution hubs, this would facilitate distribution to the wider population. However, the key tuna offloading points in Kiribati, Marshall Islands, Solomon Islands and FSM represent only one or two of the major population centres in these countries that have multiple inhabited islands and atolls. FSM, for example, includes more than 40 populated islands in an EEZ of over 2,500,000 km^2. While landing non-target species will benefit major centres directly, transport links to the other islands dictates benefits to the population as a whole. A similar situation exists in PNG where, while there are multiple ports around the islands and mainland, limited communication links to the mountainous interior hinder the distribution of benefits (Bell et al. 2011, 2015).

That vessels return to specific Pacific Island ports with processing facilities does not necessarily imply that fish are landed into port. Target tuna catches may be transshipped to carrier vessels in the safe waters of the lagoon, as in Pohnpei (FSM), rather than processed onshore (Hamilton et al. 2011), which may reduce the potential for non-target species to benefit local food security if nearshore transshipments prevent onshore access to non-commercial catches. Fishing access agreements might need adjustment to require a specific percentage of catches to be landed into local ports, or onshore supply of non-target fish. This could provide a driver for onshore processing and increased domestication of tuna fishing, both of which would increase employment, local incomes and spending power. Such arrangements are becoming more common, as in PNG where domestic fish processing plants are being developed which employ thousands of local people both directly and indirectly.

A question remains of whether PICT access to non-target catches through catch retention requirements is desirable economically. While potentially reducing reliance on imported processed foods, and reducing national exposure to global price fluctuations, retention requirements may affect national fishing revenue levels. A number of additional operating costs would be incurred by fishing companies, for example in fuel expended, and reduced revenue from vessel well space that could otherwise be filled with more valuable tuna. These additional costs incurred by vessel operators may reduce the potential license fee levels that accrue to the country whose EEZ is being fished.

Landing non-target catches for local food security also raises social issues (WCPFC 2012). There are implications for local market prices from the arrival of many tonnes of non-target fish, and potential negative competitive interactions with local artisanal fishers who supply fish to local markets and rely on those resources for their own food security. Given the logistical difficulties in developing complete census information, the total number of artisanal fishers within the region is uncertain. However, SPC socio-economic surveys indicate that 47% of coastal households across 17 PICTs earned their first or second income from selling caught fish and shellfish, when in excess of subsistence needs, illustrating the importance of fisheries for livelihoods. There may be no direct competition with industrial fisheries for the same fish stocks as local small-scale and artisanal fishers generally target different stocks to commercial purse seine vessels, although competition may occur for rainbow runner, dolphinfish and wahoo in certain areas. However, the arrival of considerable fish protein in local markets could depress the price of all fish protein, reducing local fisher income at irregular intervals.

Finally, careful monitoring of the quality of non-target fish landed from industrial fisheries for local markets must occur. Non-target species might be less rapidly processed on capture than target tuna, remaining on deck for longer in tropical temperatures, and may be less effectively stored in brine or dry freezers compared to commercially valuable tuna. This may lead to food quality issues, while lower quality and hence lower priced fish have the potential to reduce overall market prices further.

8.4.2.4 Non-target Purse Seine Fish Catches and PICT Food Security

As noted within the report from the 2010 ‘Pacific Food Summit’ (WHO 2010), individual sectors may not achieve wider PICT national food security in isolation. Current protein requirements could be met by estimated purse seine non-target species catch levels in two of the seven countries examined, but anticipated future protein requirements cannot be met by these resources alone. However, there are other potential sources of food fish that have not been examined here. For example, the level of tuna historically discarded from purse seiners because they were considered too small for canning was between 10 and 60 kg per set, which equates to an additional 200–1,500 tonnes of fish in recent years. A requirement to retain a wider range of non-target species might therefore further contribute to food security.

In comparison to the purse seine fishery examined here, a greater number of vessels operate within the WCPO longline fishery. While overall longline tuna catch is low in comparison to that of the purse seine fishery, the proportion of longline bycatch is relatively high (Brouwer et al. 2018) resulting in bycatch levels comparable to or greater than those estimated here for the purse seine fishery (Peatman et al. 2018b).

This bycatch offers further potential food security benefits. However, in contrast to purse seiners, many of those species are commercially targeted by longliners, while the more limited hold capacity of these vessels may reduce the level of 'unwanted' species. In turn, there is an increased level of longline fishing outside EEZs in comparison to the purse seine fleet, while transshipment at sea and return to distant water ports rather than those of island nations is also more common. While PICT longline fleets operating out of island ports might provide additional sources of protein, this might place them at a competitive disadvantage to other fleets. Gaining benefits from longline fleets would, therefore, require careful analysis and management.

A sustainable oceanic fisheries sector can contribute to alleviating PICT food insecurity providing a healthy source of good quality protein and micronutrients, reducing reliance on imported products and hence national exposure to global market fluctuations, and providing national income from the direct sale of commercial protein or fishing access to EEZs to support investment in other food production sectors, infrastructure and human capital. Policy decisions on the utility of the non-target catch, or indeed the target tuna catch that could readily achieve island protein food security as advocated by Bell et al. (2011), must be made at the country level, to capture national circumstances and the practicalities of access to and stability of supply, the inherent costs involved, and social implications. For example, in cases such as Nauru, where limited port facilities hamper ready access to fish for food security, it may prove better to maximise economic revenues from purse seine activity within their EEZ, and use that income to purchase cheap alternative—but healthy—protein sources for the local population, as in Fiji where locally processed tuna are exported and lower cost processed mackerel from other countries imported. This study provides a source of information to inform country and regional policy decisions on securing future food security.

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Chapter 9
Addressing Food and Nutrition Insecurity in the Caribbean Through Domestic Smallholder Farming System Innovation

Arlette Saint Ville, Leroy E. Phillip and Gordon M. Hickey

Abstract Smallholder farmers are key actors in addressing the food and nutrition insecurity challenges facing the Caribbean Community (CARICOM), while also minimizing the ecological footprint of food production systems. However, fostering innovation in the region's smallholder farming systems will require more decentralized, adaptive and heterogeneous institutional structures and approaches than presently exist. This review of the conditions that have been undermining sustainable food and nutrition security in the Caribbean focuses on issues of history, economy and innovation. It argues for a different approach to agricultural development in the CARICOM SIDS that draws primarily on social-ecological resilience and agricultural innovation systems frameworks. Research needs include a better understanding of how social capital can facilitate adaptive capacity in diverse smallholder farming contexts; how formal and informal institutions interact in domestic agriculture and food systems to affect collaboration, co-learning and collective action; how social actors might better play bridging and linking roles that can support mutual learning, collaboration and reciprocal knowledge flows; and the reasons underlying past innovation failures and successes to facilitate organizational learning.

Keywords Community-based development · Land use · Food policy · Complexity · Sustainability

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9.1 Introduction

Caribbean SIDS confront a range of general challenges to development that are both general and context-specific, including small size, insularity, remoteness, geographic isolation, and proneness to natural disasters (Angelucci and Conforti 2010). Climatic change and the intensification of extreme weather events, such as the series of typhoons that swept through the Caribbean in 2017, are adding additional layers of complexity to achieving sustainable development (Sealey-Huggins 2017). The Caribbean SIDS (Fig. 9.1) have long been recognized as being vulnerable to environmental change due to their exposure to natural hazards, limited natural resources and ecological uniqueness (Thomas and Benjamin 2018). Although they face a wide range of social-ecological vulnerabilities, their unique characteristics have made them highly desirable tourist destinations, but that too is threatened by climate change. Beyond tourism, the natural resource sector also forms a significant component of many national economies, with agriculture playing a particularly important role in supporting rural livelihoods.

Smallholder farms, defined as farmers with limited resources operating on less than two hectares (World Bank 2003), comprise nearly 90% of the farms that operate within the Caribbean Community (CARICOM) (Fig. 9.2a) and account for approx-

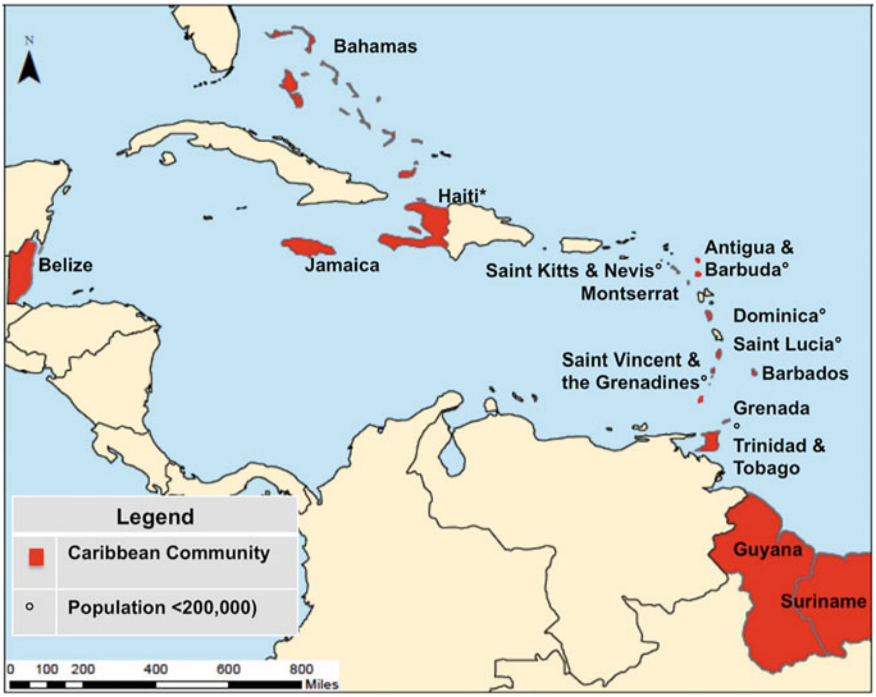

Fig. 9.1 Map of the Caribbean Community (CARICOM)

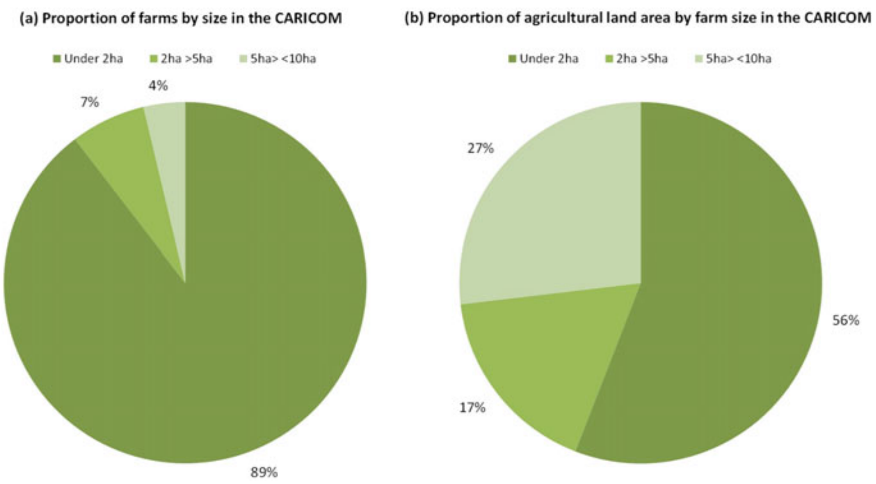

Fig. 9.2 **a** Proportion of farms by size *(n)*. **b** Proportion of agricultural land area by farm size in the CARICOM. *Data source* FAO (2012)

imately 55% of the total farmland (FAO 2012) (Fig. 9.2b). These often informal farming systems face a wide range of systemic challenges to sustainable food production that include low levels of technology, the absence of barriers to market entry, difficulties in group coordination, asymmetry in the flow of knowledge and information, and high degrees of exposure to natural shocks (Lowitt et al. 2015; Birner and Resnick 2010; Kydd and Dorward 2004), limiting their ability to compete in domestic markets flooded with imported food (Clegg and Shaw 2002; FAO 2012; Gumbs 1981).

CARICOM countries based their post-war economic development planning on the export of plantation cash crops to preferential markets in Europe (Axline 1986; Watts 1990). This agriculture-led economic development strategy resulted in agricultural institutions that were heavily directed towards export markets rather than the needs of domestic food markets (Isaac et al. 2012). Both smallholder and larger scale producers in the region were vertically integrated into value chains with coordination being managed through 'top-down' formal institutions (Saint Ville 2017a; Thomas 1988). While cash-cropping generated significant short-term economic benefits, the loss of protected markets with the advent of globalisation and trade liberalization led to a dramatic decline in agricultural production across the region (Saint Ville 2017a). Heavy focus on export markets fostered cyclical vulnerabilities in smallholder farming systems across the region, mainly due to an overexposure to exogenous shocks driven by competition from low-cost producers benefitting from economies of scale, volatility in customary markets, and unsteady foreign exchange rates (Andreatta 1998, Armstrong and Read 2002; Read 2004). Over the period 1986–2006, dramatic changes occurred across the region with CARICOM's share of global agricultural exports falling from 2 to 0.3% and the value of net

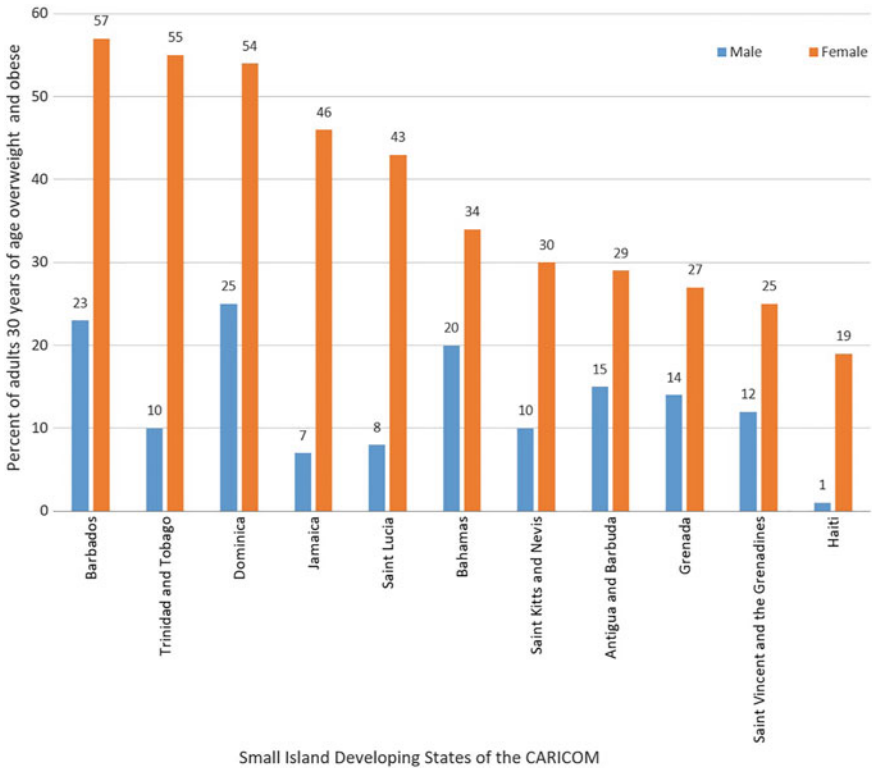

Fig. 9.3 Prevalence of overweight and obesity in the Caribbean >30 years old. *Data source* Deep Ford (2013)

agricultural exports changing from a surplus of US$2.9 billion to a deficit of US$2.2 billion over the same period (CARICOM 2007). In concert with the decline of export agriculture, CARICOM populations have been experiencing increasing rates of non-communicable diseases (NCDs), particularly obesity and overweight (CARICOM 2010) among women (Fig. 9.3) and children, raising serious domestic and international public health concerns (Lowitt et al. 2018; World Bank 2011). These health trends have been associated with an increasing dependence on imported energy-dense foods, consumer food choices that have led to low consumption of fresh vegetables and fruits, alongside sedentary lifestyles (Samuels et al. 2012).

One strategy adopted by CARICOM to address these regional challenges has been to try and realign domestic agricultural production with a view to enhancing dietary diversity and quality (Brathwaite and YongGong 2012; CARICOM 2010). However, that required a fundamental departure from past institutional approaches (sectoral, state-led, or market-led) to better account for the complexity of the local agriculture-food systems and support the multilevel innovation processes required to ensure the resilience of domestic food systems. Recognizing the significance of the challenges that face the region, this chapter reviews how institutional arrangements in Caribbean agriculture and food systems have been driving smallholder vulnerability in a cyclical manner. We first describe the conditions that have been undermining sustainable domestic food production in the region, focusing on issues of history, economy and innovation, and then argue for a different approach to agricultural development in the region that draws primarily on social-ecological resilience (SES) and agricultural innovation systems (AIS) frameworks. Working within this approach, we then discuss potential policy options and identify research needs.

9.2 Conditions Undermining Domestic Agriculture and Food Systems in CARICOM SIDS

9.2.1 History: Plantation Institutions and the Legacies of Colonization

The legacies of colonization in the Caribbean have been the subject of much study, influenced by Frank's (1969) analyses of economic development and external structural arrangements (Beckford 1999; Cooper 1993; Lewis 1968; Richardson 1992; Thomas 1988). Increasingly, however, it is being recognized that domestic institutions in ex-colonies have the potential to play a significant role in sustainable and equitable economic development (Favaro 2006; Rodrik et al. 2004; Seligson and Passé-Smith 2008). In the context of agricultural development, understanding how colonial institutional legacies have fostered export production in the CARICOM region requires examination of the role played by domestic policy and institutions (Saint Ville et al. 2017b; Rodrik et al. 2004; Seligson and Passé-Smith 2008). Recognizing this, Timms (2008) traced agricultural policy development in the Caribbean from the colonial mercantilist interests (1500–1900) to the most recent 2008 food price hikes and offered three factors driving CARICOM's export-oriented focus: in-country resistance to changing the status quo by the planter class and political elites; lack of resources to support institutional change, first by colonial and then ex-colonial powers who have been concerned primarily with their own positive balance of trade, and utilizing aid to sustain such terms of trade; and, most recently, neo-liberal trade policies that have disadvantaged small local producers through market flooding with cheaper food produced in industrial agricultural systems (Elliott and Palmer 2008).

Across the Caribbean, the 'plantation' as an institution of political colonization was both a powerful economic and social unit, surviving for over 450 years with minimal structural change (Saint Ville et al. 2017a; Beckford 1999; Beckles and Shepherd 1996), and influencing social norms, interactions and relations concerning agriculture. Caribbean plantation agriculture was a system informed by an exploitation and domination ethic that used land and labour for the extraction of maximum profit. More specifically, Richardson (1992) identified six characteristics of the Caribbean plantation institution: viewing land as a commodity; complete control of resources and their use centralized by the owner or representative; significant investment in equipment and technology for monocrop agriculture; introduced workforce controlled by coercion and/or force (slavery); production-oriented toward foreign mass markets, and supporting policies devised by foreign capital interests. Other norms associated with the plantation institution include racist and exploitative ideologies that have affected human relations in the Caribbean agricultural system (Beckles and Shepherd 1996). For example, Thomas (1988) described plantation relations during slavery as authoritarian, based on force, terror, fear and fraud. In order to supplement imported food rations, each slave was allowed one day a week to tend to their garden and exchange surplus produce. Producing food for subsistence became one of the few areas where slaves were able to enjoy the fruits of their labour and subsistence farming became the focal point of family and community life (Thomasson 1994). These interactions form the basis of the contemporary informal institutions that support domestic production and weekly farmer markets in the Caribbean.

After emancipation in 1838, slaves were freed and their legal status changed, however, their economic domination by planters remained a societal norm (Thomas 1988). For sugar, the major export crop at that time, prices fell and the region experienced economic depression, leading ex-slaves to riot against oppression, causing widespread social unrest (Watts 1990). The British colonial administration responded to the situation with what the West India Royal Commission of 1897 hailed as the "Magna Carta of the West Indian peasant" (Shephard 1947: 63), designed to deal with concerns of declining revenue from sugar production, lowering of wages, and the abandonment of plantations by freed slaves. Recognizing the highly charged conditions in the colonies, the administration moved to implement non-revolutionary changes. Land settlements were initiated to pacify landless peasants, and the development of the fruit trade was initiated, transitioning much of the region from sugar to banana production (Axline 1986; Clegg and Shaw 2002). Initially, plantation owners often blocked land settlement schemes assuming that they would increase labour shortages and negatively impact their production (Thomas 1988). Consequently, ownership of land and exchange of labour in the CARICOM region became subject to societal class divisions that still pervade society, particularly in the agricultural sector (Saint Ville et al. 2017a; Thomas 1988), and would serve to limit the proper functioning of market or economic forces. George Lamming (1981) described how these tensions impact labour availability in the region:

> [A]t the deepest levels of a man's being it cannot make sense that he should … labour for those whose style of thinking discloses them to be his enemies (quoted in Louis 1981: 222).

Eventually, under pressure from ex-slaves, land settlement schemes were implemented but they did not generate the desired outcomes. Five factors undermined these settlement plans: political expediency—lands were carved into farms of less than two hectares to increase land ownership levels among many peasants rather than into more economically viable units; low access to financial and physical capital and technology which kept production levels low; low levels of human and social capital with many farmers lacking the knowledge to design and sustain commercial operations; lack of natural capital—since plantations were already located on the fertile lands and plains, smallholders were often allocated inappropriate and marginal lands which limited production and increased land degradation; and local elites, with conflicting economic interests in the wholesale business of food imports, actively undermined agricultural investments directed toward domestic production and local markets (Saint Ville et al. 2017a; Axline 1986; Timms 2008).

> [T]he peasants of the Caribbean have been embattled since their beginnings …. agricultural or infrastructural improvement - in roadways, marketing facilities, agricultural extension and credit, crop varieties…went to the plantation sector…. Perhaps the most unusual thing about Caribbean peasantries is that any of them survived at all (Mintz 1985 p. 132).

Beyond the formal land settlement schemes, land tenure across the CARICOM region also became subject to a diverse range of informal, unclear and complex (multiple ownership) arrangements. For example, communal, indigenous and generational land ownership is still found in Suriname, Belize, Jamaica, Bahamas, Tobago, Dominica and Saint Lucia (FAO 2013). In Saint Lucia, 45% of all land parcels fall under the generational "family land" title, defined as lands owned across generations of a family that can be accessed and used by a multiplicity of heirs without title by virtue of shared bloodline (OAS 1986). These socio-historical influences on land and labour continue to pervade agriculture in the region (Saint Ville et al. 2017a). Further, the relative ease of access (not ownership) to small, subeconomic farm units serves to limit the operation of the more conventional microeconomic principles needed to support conventional commercial agricultural investment and development.

9.2.2 *Economy: Small Size of Domestic Markets*

The small size of domestic markets and the absence of economies of scale present a particular challenge to sustainable domestic agricultural sector development and regional food security for the SIDS of CARICOM. Small domestic markets, absence of economies of scale, limited economic diversification, high costs of imports, and limited private sector development are significant challenges to innovation in most sectors. In the agricultural sector, these challenges are compounded by limited natural resources, remoteness and insularity and vulnerability to natural disasters, which further undermine the resilience of domestic food systems (Blancard and Hoarau 2013). Further factors affecting development capacity and innovation in the small market economies of CARICOM include loss of skilled human capital ("brain drain"); high social cohesion among policymakers and social elites which stifles growth; and revenue shortfalls from the small population and taxation base resulting in public service limitations (Briguglio 2003; Favaro 2006). These are significant size-related challenges which limit the options and resources available to decision makers tasked with developing and reviewing the effectiveness of existing institutional arrangements.

Notwithstanding historical legacies, institutional 'lock-in', and size-related limitations, CARICOM governments have recognized the urgent need to foster innovation across their domestic agriculture-food systems to help build the adaptive capacity of rural communities and address the growing public health crises of NCDs resulting from low dietary and nutritional diversity (CARICOM 2010). The complex challenges of food insecurity became further highlighted during the global 2007–2008 food price hike, which revealed that while there had been extensive investments in agricultural science and technological developments, there had not been matching policy innovation around the institutional arrangements that support smallholder farmer systems (FAO 2013; Gamble et al. 2010; von Braun 2009). Many governments have returned to previously neglected areas of food security-related public policy since the 2007–2008 food price hikes due to a lack of confidence in the market, unwillingness of policymakers to continue dependence on the private sector to provide signals for food security decision-making, and attempts to make policy more context-driven. Analysis of the policy options implemented by CARICOM SIDS revealed that 42% had initiated producer-oriented measures (e.g. input subsidies, seed improvement, input price control), 17% trade policy measures (e.g. food imports/exports imposed or lifted) and 25% consumer-oriented measures (e.g. school feeding, price control, removal of VAT) (Maetz et al. 2011). As CARICOM searches for new, context-driven food and nutrition security policy options, the region will require a better understanding of how existing (often informal) domestic institutions function, and how they can and do inform formal agricultural sector reform policy and process.

9.2.3 Institutions, Interactions and Innovation: Lack of Formal Learning and Low Levels of Adaptive Capacity

Another significant challenge facing the agriculture and food sectors in CARICOM is the malfunctioning of institutions, involving a lack of interaction and interdependency between institutions that support learning and the absence of enabling cultural environments (Lederman et al. 2013). It is therefore important to understand how interactions between actors and institutions (i.e. common rules and procedures) in the agriculture-food system function in order to promote resilience and adaptive capacity through innovation, co-learning and collaboration (Saint Ville et al. 2017a; Bahadur et al. 2013). Institutions are central in helping (or hindering) social actors in the food system to absorb change and maintain functions (buffer capacity); self-organize and enhance learning. In order to better understand how institutions have affected the agricultural production systems operating in the CARICOM, we depict the interactions between networks of organizations and actors, together with the dominant institutions and policies (Fig. 9.4) to show how interactions between agriculture and food-related institutions have helped and hampered smallholder farmers absorb change, self-organize and learn through time. This shows that, since the 1900s, minimal institutional change has occurred in the functioning of the region's two-tiered agriculture-food system, with human, social, economic and institutional resources directed primarily towards commodity-oriented production. When comparing how

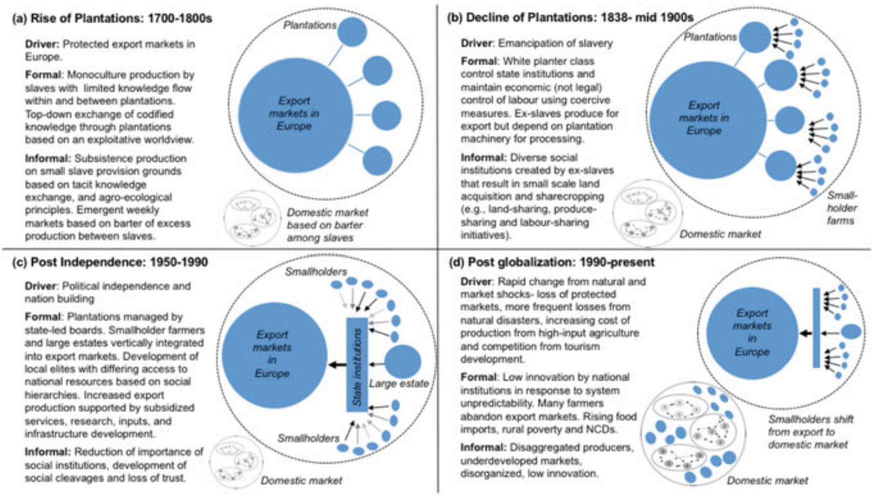

Fig. 9.4 Structural conditions underlying the development of CARICOM's two-tiered agricultural innovation system (drawing on the history of the English-speaking Caribbean). Sections **a**–**d** depict diverse drivers of change over time, juxtaposed against the institutional inertia of export-oriented formal institutions and the neglect of informal domestic markets

commodity-oriented export production and domestic-oriented subsistence production have helped social actors absorb changes, organize and learn, we can distill three main differences. First, they have different worldviews and approaches to change. In CARICOM a command and control paradigm (evolving from the plantation institution) has informed the formal agriculture and food institutions of government (Saint Ville et al. 2017b; Pant 2013). This production paradigm is based on assumptions that include a stable environment where resource flows can be controlled and nature will return to equilibrium (Wilby and Dessai 2010). In contrast, the informal agriculture-food institutions supporting production for the domestic market evolved largely organically, as diverse producers met weekly, exchanged (bartered) and later sold excess production (small volumes) of a wide variety of crops. Second, each production system fostered different social relations, levels of farmer organization and learning. Social relations, from slavery to the present day, created and maintained division between races and classes with low knowledge flows across the class divide. After the emancipation of slaves and later as part of national independence activities, land settlement schemes enabled first ex-slaves, and later smallholder farmers to become vertically integrated into export-oriented commodity production programs (Brierley 1988; Grossman 1998). These smallholder farmers received significant economic benefits from this approach until the late 1990s, ending with changes to global trading agreements. Over the same period, a smaller group of smallholder farmers oriented towards domestic markets were squeezed into a small niche initially limited to ad hoc production for weekly provision markets (Levitt and Best 1975). While export-producers were vertically integrated with linear exchanges of codified knowledge, contrastingly, weekly provision markets developed and organized in a decentralized manner, through what Hart (2005: 10) characterized as "the self-organized energies of people excluded by the exigencies of state rule". In this case, knowledge exchange was more multifunctional and needs-based, with social learning and relationships guiding tacit knowledge exchange.

The evolution of a two-tiered agriculture-food system in CARICOM has resulted in an institutional mismatch that drives smallholder vulnerabilities, supports institutional inertia in Caribbean agriculture, but also provides an entry point for future interventions to enhance innovation outcomes and overall food and nutrition security in the region (Saint Ville et al. 2017a, b). Major differences between the tiers include: knowledge types (tacit vs. codified), ethics (subsistence vs. exploitation), knowledge exchange/learning pathways (social learning vs. top-down), production principles (agro-ecological vs. monoculture), management type (self-emergent vs. authoritarian) institutional forms (informal/flexible vs. formal/command and control), major resource used (social capital vs. financial capital), coordination mechanism (heterogeneous vs. homogenous), governance (decentralized/multilevel vs. centralized/bureaucratic). Both production tiers appear to have followed parallel processes, with the formal agriculture-related institutions likely undermining the adaptive capacities of smallholder farmers. This phenomenon of dual resource management systems with conflicting objectives has resulted in an "inter-institutional pitfall" which undermines reciprocity, knowledge exchange, learning and development of common interests across institutions. Policy can bridge these gaps, foster trust and shared vision by acknowledging informal institutions and enhancing cooperation through inter-institutional processes (such as multi-stakeholder groups) supported by mediating agents (Rahman et al. 2014).

9.3 Promoting Innovation in the Domestic Agriculture and Food Systems of CARICOM

Recognizing the complex challenges that face CARICOM as it seeks to sustainably develop domestic agriculture-food systems there is an urgent need for more systems-based approaches to policy, practice and research. More specifically, the historical, economic and institutional challenges facing smallholder agriculture will require a greater focus on building agricultural innovation systems (AIS), defined by Hall et al. (2006: 12) as "networks of organizations or actors, together with the institutions and policies" that influence innovation processes and outcomes through interactive learning that results in "new products, new processes and new forms of organization". AIS thinking goes beyond previous approaches in the region, to focus explicitly on interactions between actors and their institutional and policy contexts with a view to creating enabling environments for innovation (Klerkx et al. 2012). Understanding how such interactions, interdependencies and cultural environments developed within CARICOM's agricultural innovation systems offers a potentially fruitful avenue to address the institutional mismatches that drive smallholder vulnerabilities and institutional inertia in Caribbean agriculture with a view to enhancing innovation outcomes and overall food and nutrition security. Adopting an AIS perspective also has implications for the ways in which donor agencies, governments, non-governmental organizations, scientists and communities might best approach resiliency-focused food security policy and research in the region.

Another important approach to understanding the complexity of the interactions occurring between the human and natural systems supporting agriculture and food systems in the CARICOM is through socio-ecological systems (SES) (Berkes and Folke 1998). SES approaches view human systems and ecosystems as coupled and emphasize complexity, feedbacks, systemic interactions and adaptive capacity (Foran et al. 2014). Efforts to better understand the dynamics of SESs, including how they adapt, absorb shock, and maintain key functions, have revealed important insights to the relationship between institutions and resilience (Folke 2006). More specifically, the concept of social resilience, defined by Adger (2000) as the capacity of groups or communities to adapt in the face of external social, political, or environmental stresses and disturbances, represents an often untapped resource for facilitating social-ecological resilience through adaptation and innovation (Folke et al. 2003, 2005; Pretty 2003; Pretty and Ward 2001). Recently, however, Fabinyi et al. (2014) identified the need to focus further on how social diversity, power relations, and agency affect SESs. For example, Westley et al. (2013) reviewed agency in social-ecological transformation and matched social innovation strategies with SES adaptive cycle phases, suggesting that innovation within a SES depends upon the ease with which organizations can promote joint action and the extent to which institutional structures foster the type of innovation required in that system phase.

Drawing on the literature covering the theory and application of AIS and SES frameworks in diverse contexts, a conceptual diagram (Fig. 9.5) suggests how CARICOM policy institutions might better approach the problem of low adaptive capacity in the domestic agriculture-food systems of SIDS. This is based on a recognition that responding to environmental change and shocks (social, political, economic and environmental) to domestic agriculture and food systems will need to build upon and expand existing social system agency in order to foster social transformation and innovation. According to Westley et al. (2013), this will involve questioning of arrangements, undermining existing rules and authority, and increasing interactions to foster new collaboration toward common goals. In particular, fostering innovation in the region's smallholder farming systems will require more decentralized social systems where mutually supporting relationships among diverse social actors are mediated through connections with the natural environment (Anderies et al. 2004). In our diagram (Fig. 9.5), social resilience is shown as the pivot of human-nature interactions in SIDS, cutting across the three intersecting policy domains of domestic smallholder farmers, global environmental change and regional food and nutrition security, each of which suffers from low levels of innovation and adaptive capacity. This is because any efforts to build adaptive capacity, or lessen vulnerability, will be dependent on the capacity of new institutions and social actors to buffer against disturbance, self-organize, learn and adapt across scales (Obrist et al. 2010;

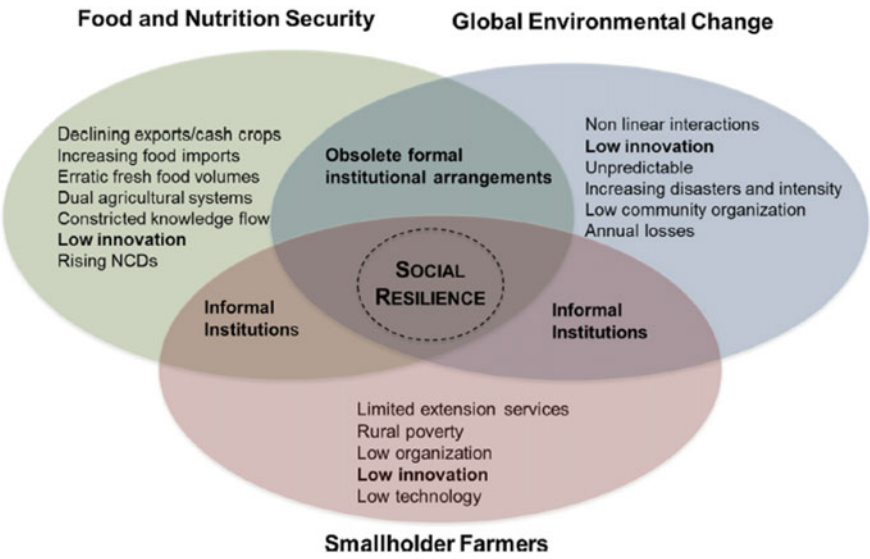

Fig. 9.5 Framework depicts social resilience operating at the pivot of human–nature interactions in SIDS, cutting across the three intersecting policy domains of domestic smallholder farmers, global environmental change, and food security; intersection of socio-ecological systems resilience in the literature; questioning and undermining of institutions (formal and informal); and need for innovation requiring increased interaction in response to shocks and crises

Tompkins and Adger 2004). The diagram also depicts the intersection of numerous complex and “wicked” policy challenges (Norton 2005) which support the need for more decentralized and systems-based approaches. Developing an integrated AIS and SES approach necessitates multi-scale analysis of livelihoods within the SES; development of multi-stakeholder processes (e.g. innovation platforms) and emphasis on governance through adaptive co-management. Our review of the literature supports the potential utility of these steps in the context of the domestic agriculture and food systems operating in CARICOM’s SIDS, and points to the following opportunities to foster innovation: facilitating institutional diversity that fosters local knowledge and governance; creating conditions that support interaction for collaboration, co-learning and adaptation at multiple scales; and supporting agro-ecological approaches to local food production systems (Bahadur et al. 2013), each of which is further discussed below.

9.3.1 Facilitating Institutional Diversity that Fosters Local Knowledge and Governance

Institutional diversity can facilitate improved local knowledge from varied sources, enhance governance structures and provide the basis for community-based development approaches (Bodin and Prell 2011; Pelling and High 2005; Tompkins and Adger 2004). The formal institutions operating in the agriculture and food systems of the CARICOM are generally characterized by a state-led focus on managing food exports with markets directing imports (Armstrong and Read 2002). In the context of British ex-colonies, Lange (2009) observed that rather than promoting broad-based development following independence, state institutions have remained relatively static, reinforcing previous colonial hierarchies and centralized power. A good example of this is the Windward Islands Banana Growers' Association, co-owned by the four Windward Islands (Dominica, Grenada, Saint Lucia, and Saint Vincent and the Grenadines), which when commercialized into the Windward Islands Banana Development and Exporting Company Limited in 1994 witnessed minimal institutional change. The importance of focussing on the issue of adaptive capacity in these relatively young institutions is supported by a recognition that promoting innovation through enhanced interactions, supportive rules and two-way knowledge flows (Berkes and Folke 1998) will require more decentralized, adaptive and heterogeneous institutional structures. These structures will be considerably different from the often authoritarian, top-down, technocratic, state-led agricultural production institutions enacted by parliament that dominate the Caribbean (Adger et al. 2005; Folke 2006; Tompkins and Adger 2004), such as the Guyana Rice Development Board (3/1998) and the Coffee Industry Board of Jamaica (146/1999). Further studies into different institutional forms and how they can influence social actors in Caribbean SIDS contexts are needed in order to provide a better understanding of how domestic agriculture and food system innovation might be enhanced in the region.

More context-specific, multilayered and polycentric institutional structures can foster more equitable governance arrangements and have the potential to counter historical social hierarchies, power differences and class divisions (Osbahr et al. 2010; Ostrom 1999). Such structures are also more suitable for enhancing the transfer of knowledge and interaction between diverse social actors (Bahadur et al. 2013; Kilelu et al. 2013). The development and maintenance of technocratic institutions in the agriculture and food systems of CARICOM have had the effect of stifling system innovation and creativity by sustaining hierarchical power differentials and limiting the evolution of more locally appropriate institutional designs (Lam 2011). This is supported by FAO (2013) who identified the need for policy reform in the region to develop institutions better tailored to small-scale agriculture. Such reforms would benefit from clear institutional diagnoses to detect constraints, highlight openings for intervention, and support the development of multi-stakeholder groups (Struik et al. 2014b). While innovative multi-stakeholder governance pathways in AIS are conceptualized as iterative and adaptive, capable of fostering learning and conflict resolution, existing deficiencies in collaboration and innovation systems may serve to limit institutional evolution and maintain the 'status quo'. In these situations, more flexible policy structures and facilitation mechanisms may help to enhance decision-making to better meet conflicting and multifaceted objectives (Kilelu et al. 2013; Klerkx et al. 2010).

In Sub-Saharan Africa, innovation platforms, which comprised of multi-stakeholder support networks operating within a geographic area, have been shown to enhance agricultural innovation by bridging critical social, economic, technical, and institutional gaps (Kilelu et al. 2013; Klerkx et al. 2013). While innovation platforms identify problems, seek opportunities and develop solutions, change agents or innovation entrepreneurs are also needed to galvanize change in complex systems which can be derailed by power dynamics and limit the effectiveness of participatory processes (Foran et al. 2014). The adaptive co-management model, which supports power and knowledge-sharing amongst stakeholders from multiple levels through reflective learning and innovation, is another approach that has already been applied in other natural resource sectors in the region (notably in fisheries, coastal zone and watershed management) (Tompkins and Adger 2004) and may offer valuable insights for domestic agriculture and food systems governance. According to Sandersen and Koester (2000), these may include how to get commitment to the devolution of state power, how to develop dynamic mechanisms to resolve conflicts, how to manage social diversity and power asymmetries, and how to enforce rules based on agreed-upon social norms.

9.3.2 Creating Conditions That Support Interaction and Adaptation at Multiple Scales

The absence of an enabling cultural environment needed to support innovation (Lederman et al. 2013) particularly within the region's historically two-tiered food production system hampers learning and knowledge exchange. More specifically, procedures are needed to govern behaviour and facilitate collaboration, co-learning and collective action for adaptation, while there is also a need to create environments that are conducive to realizing two-way communication flow (formal and informal), consensus and change (Struik et al. 2014a, b; Temby et al. 2015). These changes often require a systemic reassignment of the collective resources that created the division, effectively a massive cultural shift directed towards support for learning and adaptation at multiple scales.

Both SES and AIS approaches require substantial interaction between social actors and organizations to support institutional and cultural change and foster innovation in attitudes, values and norms from the farm to the community, private and public sectors, NGOs and wider society (Olsson et al. 2014; Westley et al. 2013). One way this can be accomplished is by mobilizing and building social capital in the form of trust, reciprocity and social networks (Folke et al. 2005) across the domestic agriculture-food systems. Social capital comprises three dimensions: bonding (horizontal within group ties), bridging (horizontal ties bridging distinct groups) and linking social capital (vertical ties to power, finance through shared tasks toward the common good) (Sabatini 2009). Importantly, not all social capital is equal, with different dimensions playing different roles in the innovation process. However social capital and innovation can be both are complementary and contradictory; while structural social capital (bridging) can enhance innovation adoption, cognitive social capital (bonding) among homogenous groups, may limit innovation by maintaining the status quo (van Rijn et al. 2012).

Studies in the Caribbean have suggested that an enhanced understanding of social capital dynamics within communities could improve policy and practice (Adger 2003; Pelling and High 2005), by encouraging social actors to co-learn and collaborate (Pretty and Ward 2001). Perhaps most importantly, the capacity of policy processes and institutions to build bridging and linking social capital across actors in the agriculture-food system will likely be directly related to their ability to overcome historical legacies of inequity and marginalization, which dominate the social memory. Social memory involves widely accepted practices based on experiences activated by a collective in response to various shocks (Folke et al. 2003). High levels of distrust between actors in the domestic agriculture-food systems of CARICOM (Lowitt et al. 2015) are embedded in the social memory that has resulted from coercion and authoritarian exploitation and may foster bonding social capital between marginalized smallholder farmers, and undermine efforts to develop bridging and linking social capital in support of innovation and collective action. Existing linking and bridging social capital between organized actors in the agriculture-food system, such as policymakers, international donors and scientists, may offer an important entry point for developing the smallholder agricultural innovation system (Fischer and Qaim 2014) through more participatory and decentralized processes of research, deliberation and decision-making that can foster trust and cross-fertilization of ideas, methods and expertise (Real and Hickey 2013).

Despite the recognized need for more flexible policy frameworks and decentralized innovation processes to support the development of social capital in the domestic agriculture-food systems of CARICOM, a significant gap remains between potential and actual practices in most countries, with negative implications for smallholder farming systems. Most agricultural extension practices in CARICOM have followed a conventional linear approach to knowledge flow, where knowledge is developed by scientific researchers and delivered through government agricultural extension officers to individual farmers. The large gap between agricultural extension theory and practice in the region stems from weak linkages between agricultural research and education; limited coordination of limited resources; and inadequate adaptation of the institutional structures to meet existing needs and resource limitations (Ganpat et al. 2009). As the region confronts the challenges of developing resilient smallholder farming systems, dynamic and organic learning systems will be needed to allow farmers to critically assess and adopt new practices or technologies. Mobilizing disconnected policy actors (e.g. farmers, consumers, health practitioners, and importers), institutions and sectors operating within CARICOM agriculture-food systems (for example through innovation platforms) can help support adaptive capacity by building trust, social capital, and widening knowledge networks, but will require redeployment of human, financial and social capital (Lowitt et al. 2015). This will also involve creating opportunities for diverse social actors to work together, develop joint visions, meet varied knowledge needs, and identify and respond to change, which may be supported by innovation platforms that seek to orchestrate change agents and connect them at different scales.

9.3.3 Supporting Agro-ecological Approaches to Local Food Production

Despite institutional similarities, the high degree of diversity in both the population sizes, from 2.9 million in Jamaica compared to 74,000 in Dominica, and natural resource bases (with Guyana having an area of 216,970 km^2 compared to Montserrat with 103 km^2), CARICOM nations necessarily offer varied opportunities for agricultural development. Complex, locally appropriate systems approaches are needed that can go beyond simplified institutional prescriptions and hopeful panaceas (Ostrom and Cox 2010) that can merely serve to limit the capacity of the domestic agriculture and food sectors to respond to change (Thompson and Scoones 2009). Agro-ecological approaches offer an alternative approach to research and policy that contrasts with the monoculture plantation approaches that have unsustainably used natural resources in the CARICOM region and left domestic food systems vulnerable to shocks (Simpson 2010). More specifically, intensive commodity-oriented production in the CARICOM has resulted in high levels of deforestation and loss of wildlife (Bramwell 2011), spiraling soil erosion (Cox and Madramootoo 1998), coral reef destruction (Pandolfi and Jackson 2006), and subsequent economic vulnerability of food systems and national economies (Andreatta 1999; Deep Ford et al. 2007). Previous research has demonstrated that agro-ecological approaches have the potential to be successfully applied in the region (Brierley 1988), however, further research and supporting policies are needed to encourage more ecologically-based agricultural production (Simpson 2010). For example, building upon proven low-input traditional agronomic practices would support livelihoods, especially pro-poor, and contribute to sustainability in these communities.

Key principles of taking an agro-ecological approach include: supporting diversity and redundancy, building connectivity, managing slow variables and feedbacks, improving understanding of social-ecological systems as complex adaptive systems, enhancing learning and experimentation, increasing participation and encouraging polycentric governance systems (Biggs et al. 2012) all of which offer important insights for how institutions and actors might foster innovation in the domestic smallholder farming systems of CARICOM. For West Africa, Struik et al. (2014a) posed four questions that may also help guide CARICOM member states to better approach agro-ecological approaches to local food production: How can context-driven change be sustained in dynamic agro-ecological settings? How can practice build on best practice in institutional innovation to build resilient agro-ecosystems? How can dual goals of sustainable intensification and improved pro-poor rural livelihoods be aligned? and How can policies be designed to protect smallholder farmers against global market shocks? Science has an important role to play in this by developing new tools that integrate mixed data sources to inform decision-making; conducting assessments based on multiple criteria that can be used to prioritize, evaluate and predict impacts and trade-offs at different scales and enhancing knowledge development on local species and traditional practice to assess their contribution to developing sustainable food systems (Caron et al. 2014). However, researchers and policymakers should not romanticize traditional practices which may limit smallholder farming systems in realizing their potential, resulting in 'poverty traps' that sustain low soil fertility and can prevent the adoption of good agricultural practices.

9.4 Conclusion

Fifty years since their independence, CARICOM SIDS continue to grapple with distinctive food and nutrition security challenges that have resulted from historical plantation legacies that support cyclic vulnerability within a two-tiered agriculture-food system. These challenges range from degrading natural resources, declining exports and rural livelihoods, high production costs, small populations and domestic market size, increasing food imports, growing rates of NCDs, and disaster proneness with production difficulties following environmental change. Improving adaptive capacity in the domestic agriculture-food systems of CARICOM will require enhanced coordination, collaboration and innovation. However, export policy 'lock-in', limited investment in agricultural development, structural openness with associated susceptibility to economic, environmental and political change and inattention to the unique social-historical context of the region have limited attempts to revitalize national and regional policies and practices.

By combining AIS and SES frameworks in the context of CARICOM smallholder farming system innovation, this chapter identifies social resilience as the pivot point for improving human-nature interactions and points to the following opportunities to foster innovation: facilitating institutional diversity that fosters local knowledge and governance; creating conditions that support collaboration, co-learning and adaptation at multiple scales; and supporting agro-ecological approaches to local food production systems. More specifically, we highlight how resilience and innovation in CARICOM smallholder farming systems could be enhanced through greater interaction among social actors and institutions, allowing them to better navigate the ill-defined issues, power hierarchies, and limited collective learning processes that generally exist in the region. Research gaps include the need to better understand how social capital and cohesion can facilitate resilience in diverse smallholder farming contexts; how formal and informal institutions interact in domestic agriculture and food systems to constrain or provide opportunities for collaboration and collective action; how social actors might better perform bridging and linking roles (e.g. innovation champions, knowledge brokers) to support mutual learning, collaboration, reciprocal knowledge flows; and the reasons for past innovation failures and successes in the region to facilitate organizational learning. Ultimately, there is a need to increase the interactions, knowledge flows and interconnections between the formal and informal institutions and diverse social actors who drive domestic agriculture-food systems in the CARICOM.

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Chapter 10
Knowledge, Markets and Finance: Factors Affecting the Innovation Potential of Smallholder Farmers in the Caribbean Community

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Abstract The need for domestic smallholder farming systems to better support food and nutrition security in the Caribbean is a pressing challenge. The Caribbean Community (CARICOM) faces complex socioecological challenges related to historical legacies of plantation agriculture, small population sizes, geographic isolation, jurisdictional diversity and proneness to natural disasters, all of which underscore the importance of fostering system-wide innovation potential. This paper explores the factors that are impacting the innovation potential of smallholder farming house-

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holds in four CARICOM small island developing states (St. Lucia, St. Kitts-Nevis, Trinidad and Tobago and Guyana) using data collected through producer household surveys, focus groups and key informant interviews. Results indicate that a systemic lack of access to finance, markets and knowledge networks is perceived as limiting smallholder innovation potential in the region. Compounding these challenges was a pervasive lack of trust reported between actors and institutions throughout the agricultural innovation system hindering the potential for collective action. This points to the need for more decentralized governance approaches that are capable of establishing stronger relationships between actors and institutions to enhance knowledge flows in support of regional rural development and food and nutrition security.

Keywords Food security · Agricultural policy · Adaptive capacity · Resilience · Institutions · Innovation

10.1 Introduction

Caribbean agriculture is undergoing substantial restructuring as it shifts from a system centrally organized around export production to an increasingly focused on domestic markets (Weis 2004, 2007; Saint Ville et al. 2015). Beginning with the rise in the plantation institution in the seventeenth century, Caribbean agricultural resources were primarily directed towards producing commodities for global markets (Axline 1986; Beckford 1972). However, by the late 1980s, this export-oriented system began to struggle in the face of globalization and trade liberalization processes (Ford et al. 2007; Weis 2007). As a result, the large-scale production of many plantation cash crops such as sugar, bananas and cocoa, and the national institutions that supported their development, production and marketing have collapsed (Weis 2007). While some farmers have begun the transition towards more locally oriented farming systems, others are leaving agriculture for employment in sectors such as tourism and construction (Clarke and Barker 2012; Pemberton 2005). However, as the global food economy becomes even more integrated, those continuing to pursue agricultural livelihoods struggle to compete due to disparities in scale, technology and production support (Weis 2004). At the same time, the region's food import bill has been rising, totaling approximately 4.25 billion US dollars in 2012 (FAO 2013).

Agricultural decline is part of a broader set of development challenges facing rural communities in the Caribbean. While overall poverty levels in the region have fallen over the last several decades, the rural poverty rate remains about twice as high as that of urban areas (IFAD 2014). Furthermore, labour force participation rates remain low among youth and women, contributing to high rates of outmigration of rural youth and creating challenges for the future of rural economies (ECLAC 2005). Exacerbating these challenges is a lack of strong rural institutions, including low levels of public investment in education and health services (IFAD 2002), and the absence of a comprehensive rural development strategy to strengthen social and economic well-being and resilience (ECLAC 2012).

Environmental change processes are also affecting the potential for sustainable rural development in the region's many small island developing states (SIDS) (Angelucci and Conforti 2010) due, primarily, to their small physical size, exposure to natural hazards, limited natural resources, small economies and deep integration into global markets (Pelling and Uitto 2001; Wong 2011). Annual climatic variability and worsening extreme weather events linked to climate change are further intensifying these regional challenges and underscore the importance of fostering system-wide innovation capacity (Birner and Resnick 2010; Blancard and Hoarau 2013; Gamble et al. 2010; Ganpat and Isaac 2014; Kydd and Dorward 2004; Robinson 2018).

Over the last two decades, the Caribbean Community (CARICOM), an economic grouping of 15 countries, mostly SIDS, has paid increasing attention to the role that a revitalized agricultural sector can play in sustainable rural development and food security (CARICOM Secretariat 2004, 2007, 2011a). A landmark effort was the 'Jagdeo Initiative', a strategy proposed in 2004 by the former President of Guyana for repositioning CARICOM agriculture in a framework of balanced rural development that meets domestic food security needs while supporting a competitive agricultural sector (CARICOM Secretariat 2004). The Jagdeo Initiative identified a number of binding constraints and accompanying interventions to enhance food security and agricultural development in the region, emphasizing the need for institutional realignment away from traditional structures to those better able to support diversified products and markets (CARICOM Secretariat 2007). Underlying the Jagdeo Initiative was a recognition that the unique limitations of individual SIDS, including their small natural resource bases, limited financial and human resources and high transaction costs to trade, necessitated regional collaboration, particularly in a context of increasing environmental and economic changes (CARICOM Secretariat 2004; Ford et al. 2007). Following the Jagdeo Initiative, in 2010, CARICOM Heads of Government endorsed a Regional Food and Nutrition Security Policy in order to provide a coherent framework for food security action and collaboration across sectors and countries (CARICOM Secretariat 2011b).

Through these policy processes, the need for greater innovation in the region's diverse smallholder agricultural systems has been identified (FAO 2013; Saint Ville et al. 2015, 2017). Innovation is here seen as an idea, practice or process perceived as novel by a social actor (Rogers 1983). Importantly, the innovation potential of social actors and institutions in smallholder farming systems is closely related to their adaptive capacity in the face of shocks (Eriksen et al. 2009; Olwig 2012; Walker et al. 2004). According to Amaru and Chhetri (2013: 129), adaptation is innovation, with the ability to innovate representing a key adaptive mechanism that is 'mediated through existing social and institutional factors and may be executed by multiple actors'. Agricultural system innovation can, therefore, occur at many scales (individual, household, community and national levels) and along many dimensions including technology adoption, institutional change, supply chain reorganization and market development (Klerkx et al. 2010). Despite the recognized importance of innovation across the diverse food and agriculture systems operating in CARICOM, few empirical studies into the factors affecting agricultural innovation potential in the region are available. This chapter responds to this knowledge gap, focusing on the challenges and opportunities facing smallholder farming households in four CARICOM SIDS: St. Lucia, St. Kitts-Nevis, Trinidad and Tobago and Guyana.

10.2 Methods

Working within an exploratory multiple case study research design (Yin 2003), we employed a mixed methods approach to data collection and analysis in each country (Creswell and Clark 2011). Due to the dearth of contemporary empirical research on smallholder farmer innovation and adaptive capacity issues in the Caribbean, an exploratory research approach was most appropriate to enable flexibility and generate more integrative insights.

10.2.1 Study Areas

Each of the four countries (Fig. 10.1) has a large rural population (in proportion to the total population), and each lists agriculture among the major industries supporting their economy (Table 10.1). More importantly, each is a member of CARICOM and therefore working towards the same set of regional food and nutrition security objectives. As former colonies, these countries also share institutional and historical legacies, most notably slavery and plantation-based agricultural production and strongly hierarchical systems of authority (Mintz 1985; Saint Ville et al. 2015; Thomas 1988).

A number of differences between the four study countries allow us to capture some of the socioecological diversity present in CARICOM. First, in contrast to the three island countries, Guyana has considerably more arable land and relatively abundant water resources available for agricultural production. Among the three island countries, Trinidad and Tobago is larger in land size and less reliant on its agricultural sector, with substantial economic revenue being derived from oil and gas development. The study countries also capture the cultural and ethnic diversity characteristic of the region. For example, in Guyana and Trinidad and Tobago, a large proportion of the population is of East Indian origin, while in St. Kitts-Nevis and St. Lucia the majority of the population is of African descent. This diversity allowed us to explore the critical factors influencing agricultural system innovation in different settings, thereby strengthening the reliability of our findings and their applicability to regional food security policy discourse.

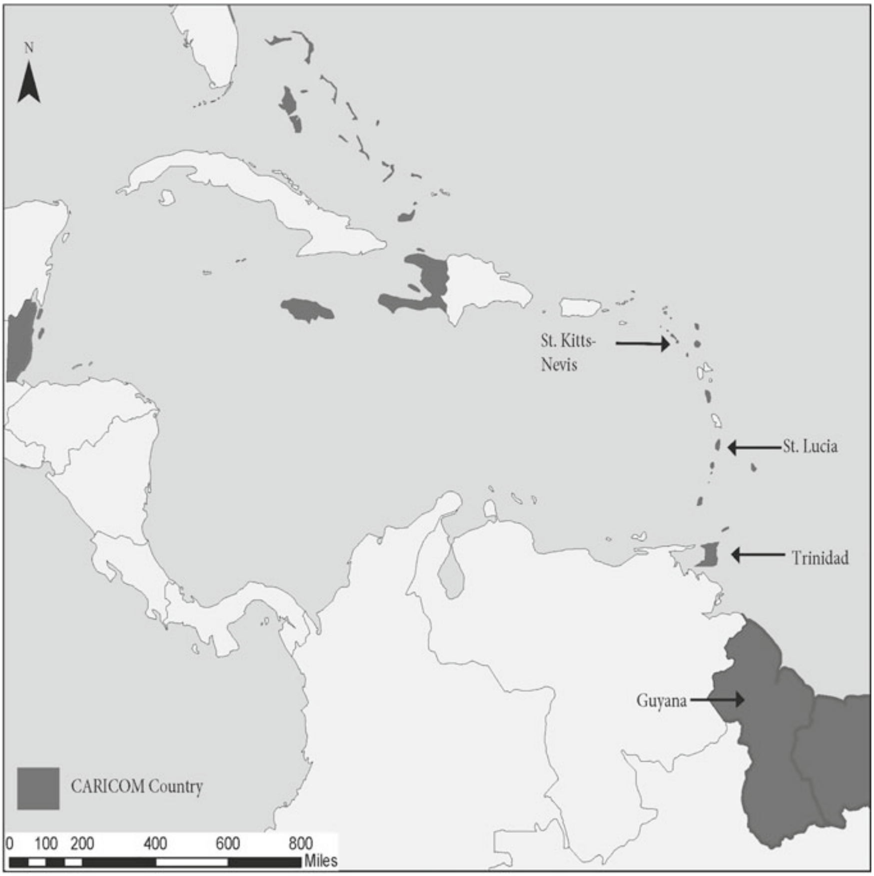

Fig. 10.1 CARICOM region and case study countries

10.2.2 Data Collection and Analysis

Data collection involved surveys, focus groups and in-depth interviews, all conducted between 2011 and 2014. A producer (farmer) household survey was designed to capture information on the specific challenges and opportunities smallholder farmers experienced in relation to food production in each country. Focus groups and in-depth interviews were conducted with smallholder farmers and other actors in the agro-food systems in each country, to further contextualize the survey results. This resulted in a broad and integrated base of evidence from which inferences for regional policy and practice could be drawn. Combining qualitative and quantitative methods also facilitated data triangulation (Creswell and Clark 2011).

Between October 2011 and August 2012, we conducted a non-probabilistic producer household survey (PHS) of smallholder farmers (n = 606) in St Kitts-Nevis

Table 10.1 Comparative summary of the key characteristics of each study country

	St. Lucia	St. Kitts-Nevis	Trinidad Tobago	Guyana
Location	Island country in the Windward Islands	Two-island country in the Leeward Islands	Two-island country in the Windward Islands	Country on the north coast of South America
Land area	616 km^2	261 km^2	5,128 km^2	214,969 km^2
Population (2018)	165,510	53,094	1,215,527	740,685
Urban population	18.7% of total population	30.8% of total population	53.2% of total population	26.6% of total population
Economy (2017)	$2.542 billion USD	$1.55 billion USD	$42.85 billion USD	$6.3 billion USD
GDP per capita income	$14,400 USD	$28,200 USD	$31,300 USD	$8,100 USD
Major industries	Tourism, light manufacturing, service, agriculture	Service, tourism, agriculture	Oil and gas, mining, construction, service, agriculture	Agriculture, mining, service

Source CIA The World Fact Book 2018. Retrieved online https://www.cia.gov/library/publications/the-world-factbook/

(n = 91), St. Lucia (n = 118), Trinidad and Tobago (n = 93) and Guyana (n = 304). Smallholder farmer households were selected from local agriculture registries provided by local project partners in each country. An initial version of the questionnaire was pretested in all four countries to improve clarity and to reduce the potential for survey bias (Laszlo et al. 2013, Thompson-Colon 2013).

The main survey respondent was the person in the household who owned, managed or cultivated land used for farming and/or raising livestock and who was responsible for most daily farming decisions. Farmers were asked socio-demographic and health questions, regarding themselves and all members of their household, and questions related to household food sufficiency, household income, household decision making, farming practices, technology adoption, access to markets and attitudes towards risk. The household survey was designed to be exploratory in nature, so the results are appropriate for generalization to theory, rather than to populations (Yin 2003). We, therefore, present the results in a descriptive rather than explanatory manner and rely on other data sources to triangulate the survey findings and assess reliability.

Key informant interviews and focus groups were undertaken in each country with a range of actors in the smallholder agricultural innovation system including farmers, policymakers and community leaders and members. Specific research tools and participants varied by country, reflecting the different regional research contexts and the exploratory nature of our research. However, data in each country were collected around common themes of smallholder farmer innovation (including access

Table 10.2 Qualitative research activities

Research activity	Participants	Theme	St. Lucia	St. Kitts	Trinidad	Guyana
Interviews	Smallholder farmers	Social capital, farmer innovation	$n = 25$	$n = 39$		
Interviews	Policymakers, community members and leaders	Social capital, institutional innovation, policy change	$n = 64$	$n = 26$	$n = 19$	
Focus groups	Smallholder farmers	Social capital, farmer innovation	$n = 75$			$n = 163$
Focus groups	Farmers, policymakers, community members and leaders	Social capital, institutional innovation		$n = 13$	$n = 35$	

to resources and knowledge), social capital and institutions and policy. Table 10.2 summarizes the qualitative research activities conducted across our four study countries. Qualitative data were transcribed and analyzed using content analysis, with grounded theory's constant comparative method used to guide memo writing and coding. Throughout the results and discussion, we present illustrative quotes wherever possible to capture the overall sentiment in our dataset and better contextualize the findings.

10.3 Results and Discussion

10.3.1 Challenges Facing Smallholder Agricultural Innovation Systems

Table 10.3a–d presents the demographic characteristics of the surveyed farming households. Several of these characteristics can be associated with low levels of innovation potential, including relatively low levels of formal education and land ownership. Overall, just less than half (48%) of all surveyed farmers had completed secondary school (average values ranged from 19% in Saint Lucia to 68% in St. Kitts-Nevis). Previous research suggests that low levels of formal household education constrain farmers' capacity to adopt new practices and technologies and acquire more specialized skills and training (Dahkil and Clercq 2004; Huffman 1999). Our survey also revealed variable patterns in land and farm ownership. Currently, government is the largest landowner in CARICOM, and many countries have introduced various land reform programmes and policies to address historically uneven land ownership (IICA 2013; Williams 2003).

However, across the region, uncertain title to land for agricultural and residential use persists (IICA 2013; Williams 2003). Specifically, our survey indicated that although the level of dwelling ownership is high at 91% (ranging between 78% in St. Kitts-Nevis and 95% in Guyana), the level of ownership of the land on which the dwelling was located is considerably lower at 67% (ranging between 35% in St. Kitts-Nevis and 78% in Guyana). Land tenure is an important factor shaping household vulnerability to environmental and socioeconomic shocks, with households living on land with insecure tenure often particularly vulnerable to displacement following natural disasters and low levels of access to credit (Reale and Handmer 2011; Williams 2003).

Relatively low levels of farm ownership existed among our sample (65%). However, this varies considerably between countries, with only 8% of surveyed farmers in St. Kitts-Nevis owning their farm, compared to 89% in Guyana. More secure farmland tenure is generally associated with more profitable and sustainable agricultural production, with positive implications for household income and food security. Insecure land tenure may deter investment in agricultural infrastructure, and, if a tenure system allows land sales, could result in the loss of livelihood in the event of a severe shock (Maxwell and Wiebe 1999; Reale and Handmer 2011). Land tenure interacts with environmental change in complex ways. For example, in St. Kitts, 73% of surveyed farmers identified wildlife pests, particularly monkeys, as a constraint to successful production. Wildlife pests have become worse in recent years as the measures used to previously control them in the export-oriented agricultural system are no longer in place. Some farmers indicated that this was compounded by their not owning farmland, making them unable to live on the farm and thereby potentially scare away wildlife pests.

Sixteen percent of the farming households surveyed were headed by women (Table 10.3). Research in many developing area contexts has shown that women face a unique set of livelihood vulnerabilities related to constrained access to agricultural resources, including land, credit and inputs (FAO 2011). Focus group discussions also indicated that women often worked on other farms because they could not access the resources needed to farm on their own. For example, a female farm labourer in Guyana said, '…most of us labour under the, let's say the merchants. That is how we get our income, that is how we get our resources. We are living on the surplus'.

The overall results (Table 10.3e) indicated that smallholder farmers perceive a range of barriers to successful farm production with access to finance, markets and information and knowledge emerging as the key barriers to smallholder agricultural innovation.

Table 10.3 Characteristics of smallholder farming households surveyed in St. Lucia, St. Kitts, Trinidad and Guyana

Variables	Mean	Standard deviation
(a) Household head		
Female (0/1)	0.16	0.371
Married (0/1)	0.72	0.451
(b) Education		
Primary (0/1)	0.38	0.485
Secondary (0/1)	0.48	0.500
College/University	0.09	0.280
(c) Home and property ownership		
Owns home (0/1)	0.91	0.279
Owns land on which home is located (0/1)	0.67	0.470
(d) Farm characteristics		
Years of farming	20	11.9
Farm size (acres)	8.3	42.2
Farm ownership	0.65	0.478
(e) Agricultural production constraints		
Lack of finance (0/1)	0.60	0.491
Lack of information (0/1)	0.20	0.403
Lack of technical assistance (0/1)	0.26	0.440
Weeds, pests, diseases (0/1)	0.64	0.481
Humidity, heat (0/1)	0.11	0.314
Flooding (0/1)	0.46	0.499
Drought (0/1)	0.14	0.351
Larceny (0/1)	0.19	0.393
Wildlife pests (0/1)	0.23	0.419
Government agriculture policy (0/1)	0.20	0.397
Timely availability of inputs (0/1)	0.16	0.368
Marketing (0/1)	0.29	0.454
Farm accessibility (0/1)	0.09	0.288
(f) Access to markets: Farmer buying contracts for crops		
Formal (0/1)	0.20	0.399
Informal (0/1)	0.49	0.500
None (0/1)	0.31	0.464
(g) Technologies and assistance		
New technology adopted in past 12 months (0/1)	0.38	0.486
Technical assistance sought[a] (0/1)	0.26	0.441
Source of technical assistance[a] (n = 160)		

(continued)

Table 10.3 (continued)

Variables	Mean	Standard deviation
Friend	0.16	0.365
Ministry of Agriculture	0.02	0.150
University	0.002	0.041
Retailers (e.g. agricultural input stores)	0.11	0.318
Internet	0	0
Research institutions—Caribbean Agricultural Research and Development Institute (CARDI)/National Agricultural Research and Extension Institute (NAREI)	0.20	0.400
Other (e.g. family member)	0.03	0.165
Data source PHS 2012; Total $n = 606$		

[a]Only farmers who had adopted a new technology were asked this question

10.3.1.1 Finance

Lack of access to finance was both a key constraint to smallholder production and a barrier to agricultural innovation. For example, in interviews with crop farmers in St Kitts-Nevis, the issue of financing was raised often, regarded as limiting their ability to diversify into livestock production, due to the need to invest in fencing and shelter for animals and to improve water infrastructure for irrigation which would allow diversification and increased crop production. Many farms are rainfed and long dry seasons strain production and contribute to crop losses. Compounding this challenge was that many smallholder farmers did not own farmland to use as collateral in securing a loan (Table 10.3d) for irrigation and other infrastructure.

In the context of group-based capital raising initiatives, some groups were able to access financing to purchase tools and equipment that they could not have done individually. However, other groups faced a new set of constraints in accessing finance. For example, a member of a registered farmers' cooperative in St. Kitts-Nevis explained that eligibility for financing and other sources of funding required the cooperative to maintain a minimum number of paying members. However, collecting membership fees from farmers, many of whom face financial constraints or are only farming part-time, is a challenge that hinders their ability to access financial support. The imposition of external accounting standards and other regulations has been recognized as a barrier to agricultural cooperative development in many parts of the world (Markelova et al. 2009). Our Caribbean data support the increasingly recognized potential for microfinancing institutions to enable farmer innovation through an appropriate policy and regulatory framework (Ellis 1999; Olaitan 2006).

10.3.1.2 Markets

Market access emerged as a second significant constraint facing smallholder farmers in our study. Across our sample, smallholder farmers were selling their produce primarily to local domestic markets, including supermarkets and public markets. However, only 20% of farmers had formal contracts for accessing these markets, with nearly all relying on informal arrangements or no contracts at all (Table 10.3f). This points to a key vulnerability in the domestic food production systems of CARICOM, with a lack of established formal market connections restricting access to the information that smallholders need to participate effectively in markets such as current prices and product demand (Robbins et al. 2005; Markelova et al. 2009). Many smallholder farmers described their vulnerability to inconsistent purchasing on the part of supermarkets and to receiving a viable price for their produce.

In reference to having to accept the price offered by supermarkets, a female farmer in Guyana said, ‘We can’t do anything’. Similarly, a female farmer in St. Lucia said, ‘What else would you do? Even if everybody has the same thing, when you want your produce to sell, you just sell it cheaper’. A recurring challenge associated with markets was the need to compete with imported foods, particularly fresh fruits and vegetables. The contractual agreements between supermarkets and food importers that were seen as limiting the willingness of supermarkets to sign contracts or purchase more produce from local farmers. For example, a farmer in Saint Lucia said: ‘I know there are sometimes [locally produced] tomatoes spoiling… and go into the supermarket you would still see imported tomatoes’. Economic and trade liberalization reforms beginning in the 1980s have had the effect of reducing domestic controls on trade and import tariffs which are needed to protect smallholder farmers in SIDS (Ford et al. 2007). During these reforms, many government-owned agricultural enterprises were sold to the private sector (FAO 1995). A senior policymaker in St. Kitts-Nevis described how the country’s Central Marketing Agency, established in the early 1980s to buy food crops from farmers, was ‘the first one [government enterprise], easiest one to close’ as the country shut down public entities due to structural adjustment programmes. This closure resulted in the removal of a key marketing support institution for domestic smallholder farmers.

As smallholder farmers around the world are increasingly vulnerable to liberalizing markets, a growing body of research is examining how collective action can be supported among farmers to improve market access (Devaux et al. 2009; Markelova et al. 2009). Sandler (1992: 1) described collective action as taking place ‘when the efforts of two or more individuals are needed to accomplish an outcome’. Drawing on a range of international agricultural case studies, Markelova et al. (2009) found that smallholder farmers acting collectively may be able to reduce transaction costs of accessing inputs and outputs, obtain market information, tap into high-value markets and potentially improve their bargaining power with buyers. While most farmers in our sample described selling independently to supermarkets and public markets, there is evidence of successful group marketing efforts on the part of small commodity groups or farmers’ cooperatives in the region. For example, the Black Bay region of St. Lucia has an active Farmer’s Cooperative originally launched as a pilot project in 1974 to boost economic activity in the region and increase farm production through collective farming and product marketing (IICA 1989). Nonetheless, evidence from all four countries indicated that getting smallholder farmers to work together, including responding to market demand, was extremely challenging. A senior policymaker in Trinidad and Tobago spoke to this difficulty: 'We have serious challenges with implementation of anything and carrying it forward…our farmers are not organized. Biggest ingredient is having farmers organized whether it's an association or a co-op'. Low level of trust among farmers was a recurring theme in our data, resulting in fragmentation between individual farmers and within farmer groups. For example, a female farmer in Guyana explained, 'The people [farmers] need to get up and network and that unity together is an issue'. A senior policymaker in St. Kitts-Nevis pointed to the historical dimensions of trust and working together: 'Everybody just wants to be independent. It's a culture. If you go back to history, our ancestors came to work on sugar plantations as slaves. After you had a period of indentured servitude where you're expected to work for somebody. I think it comes from that culture. They don't trust one another'.

While getting farmers to work together can be difficult, a female farmer, active in organizing farmers in St. Kitts-Nevis, suggested that a proliferation of 'too many small groups, each doing their own thing' further hindered broader collective action. As the capacity to innovate becomes increasingly linked to an ability to act collectively (Adger 2010; Subramaniam and Youndt 2005), there is a crucial need to build social capital among farmers to overcome mistrust and social fragmentation (Agrawal 2001; Lowitt et al. 2015; Nahapiet and Ghoshal 1998; Saint Ville et al. 2017). Enhanced social capital among farmers may not only improve the capacity for collective action in marketing but also support the social cohesion necessary for addressing other production constraints identified by our sample of farmers such as larceny. For example, research indicates that social capital, manifested in terms of improved social connectivity and shared norms, can play an important role in reducing crime in poor and rural regions (Barnett and Mencken 2002; Warren et al. 2001).

10.3.1.3 Information and Knowledge

Another challenge to smallholder production in the region was access to information and technical assistance (see Table 10.3e). For example, a farmer interviewed in St. Kitts- Nevis, when asked about where he acquired information, explained: 'I don't go to anyone….because there's no group around here. No one to ask a question about what to do, what not to do'. The survey results related to seeking technical assistance and adopting new technologies provide further insights into the fractured nature of agricultural knowledge networks for smallholder farmers in the region.

Farmers were asked whether they had adopted any new technologies (including a new crop, irrigation technique, pesticide, fertilizer and record-keeping technique) over the past 12 months. Results indicated a fairly low level of technology adoption at 38% (ranging from 18% in St. Kitts-Nevis to 51% in Guyana), with only a subset of these farmers seeking technical assistance (Table 10.3g). Among farmers who did seek technical assistance, the most common sources of assistance were research institutes (20%) and friends (16%), including other farmers. The importance of friends as a source of technical assistance points to the significance of decentralized knowledge networks and social learning for accessing information, a theme that is emerging in the study of natural resource management issues around the world (Berkes and Ross 2013). For example, a farmer in St. Kitts-Nevis explained: ‘I try to keep contact with certain farmers. We discuss and share ideas and methods, seeds, and different things’. Some said they learn through farming knowledge passed down from other farmers as well as their parents and grandparents. A young farm worker in St Lucia explained: ‘When a farmer has just entered into farming, he has to gain experience from the more mature farmers and set about learning how to go about the process correctly’.

As many farmers move into horticultural crop production from plantation crop export agriculture, access to knowledge networks is key to increasing their innovation potential and adaptive capacity (Ganpat et al. 2014a, b; Hagmann and Chuma 2002; Ingram 2008; Isaac et al. 2007). We identified instances of farmers’ experimenting with new vegetable crops and not continuing with their production because of weed, pest and diseases problems, a key constraint identified by farmers (Table 10.3e). Lack of knowledge emerged as a barrier to improved growing practices; many farmers described operating in an agricultural knowledge and information vacuum, significantly undermining their adaptive capacity in the event of environmental or market-related shocks. For example, a farmer in St. Lucia, when asked about how they decide what to grow, said: ‘For me, anything I can plant, I plant, as I can make a dollar. As long as it comes to my mind…Yes I try anything I can lay my hands on’. Another farmer in Guyana likewise described learning about farming as ‘luck and chance’. These findings point to the need for new approaches to agricultural research and extension in the region that more explicitly embrace decentralized knowledge networks better capable of accounting for the complexity of the smallholder farming systems (Saint Ville et al. 2016; Foran et al. 2014; Isaac et al. 2007).

10.4 Opportunities for Fostering Smallholder Agricultural Innovation Systems

Overall, very low levels of trust were consistently reported among the different actors and institutions involved in the CARICOM smallholder agricultural innovation system. This is a key conclusion that warrants urgent research and policy attention in the region, particularly in the context of fostering interinstitutional collaboration in pursuit of household food security and sustainable rural livelihood goals (Lowitt et al. 2015). More specifically, there is a need to better consider how institutional structures—from local cultural norms to formal government policy (Foran et al. 2014)—influence the innovation potential of smallholder agricultural innovation systems in CARICOM. According to Kilelu et al. (2013), innovation occurs through collective interactions among farmers, researchers, extension officers, service providers and others, who are all influenced by diverse interests, values, norms, technologies, markets, institutions and infrastructural resources. As a result, there is a need to facilitate interactions between multiple actors to enable them to embrace the perspectives of others and think reflexively about their interactions with a view to strengthening cooperative relations within their given institutional context (Hall et al. 2003).

Internationally, the concept of 'innovation platforms' has been emerging as a potentially powerful approach to supporting actor-driven innovation in different institutional contexts (Foran et al. 2014). Kilelu et al. (2013: 66) defined an innovation platform as a 'multi-actor configuration deliberately set up to facilitate and undertake various activities around identified agricultural innovation challenges and opportunities'. Innovation platforms work to build capacity among actors, including communication, participatory planning and network facilitation and can act as models for broader agricultural research and development planning (Adekunle and Fatunbi 2012; Foran et al. 2014). Based on our conclusions, we can conceptualize how innovation platforms might enable different forms of social capital to be developed in smallholder agricultural innovation systems in order to foster trust and collaboration among actors. Saint Ville et al. (Chap. 13, this collection) also offer insight into how different forms of social capital affect smallholder innovation, focusing on St. Lucia as a case study.

First, bringing together farmers and farmer groups in innovation platforms may assist with developing the bridging social capital necessary for farmers to better access wider networks of information and support for the issues they face. Bridging social capital essentially connects normally distinct groups such as different farmer groups or farming communities, with similar levels of power (Sabatini 2009). Our results indicated that many farmers were not accessing support when attempting to introduce new technologies. The development of stronger peer-to-peer connections between farmers in different communities has the potential to improve agricultural knowledge flows and improve opportunities for social learning (Pretty and Smith 2004). Enhancing the bridging social capital among farmers in CARICOM SIDS may also help facilitate wider dissemination of technical knowledge from other sources such as extension officers or training workshops provided by other organizations. Here, decentralized approaches to social learning such as farmer field days and informal networking events, may prove valuable for building trust and networks between farmer-level actors (Lyon 2000; Megyesi et al. 2010). One example from our study was the organization of monthly group hikes to promote networking and teambuilding among government employees and others working in the agricultural sector. As bridging social capital forges new links between farmers and other farmer-level actors, it may help generate the social cohesion and trust that is necessary for collective action on issues such as financing, marketing and political lobbying, enabling farmers to work together to address their shared production constraints (Cramb 2005; Woolcock and Narayan 2000). A senior policymaker in Trinidad and Tobago said: 'There's a wide number of small farmers that all contribute to food security, but we have to try to get them to understand if we bring them together it will be better'.

Second, institutional change at levels higher than the farm and community is also needed for agricultural innovation (Hounkonnou et al. 2012; Shiferaw et al. 2009). Here, building linking social capital through innovation platforms—that is the vertical linkages among actors with different levels of power such as farmers, scientists and policymakers—will be key to establishing institutional environments that are more supportive of innovation (Foran et al. 2014). Linking social capital among these actors can encourage the 'productive cross-fertilization of ideas, methods and expertise' in support of institutional change (Brooks and Loevinsohn 2011: 195) and help ensure a wider range of factors are taken into account in decision making (Tompkins and Adger 2004). Further, enhanced communication among farmers, scientists, extension officers and policymakers can help generate more integrated knowledge, drawing on scientific and local bases, to better enable farmers to realize their capacity to innovate (Eidt et al. 2012; Eriksen et al. 2009; Klerkx et al. 2012; Reed et al. 2007). For example, a government technical officer in our study identified a need for better linkages among researchers, extension officers and farmers so that 'we can use it [research] to empower people'.

However, putting innovation platforms into practice is complex and will require significant institutional and policy support (Klerkx et al. 2010). As noted by Foran et al. (2014: 90), innovation platforms have 'inherent complexities and tensions' as different interests and actors need to coalesce around a shared innovation goal and subsequently require explicit efforts to ensure the meaningful representation of all actors, especially smallholder farming households and communities. Here, the use of 'innovation brokers'—key individuals or organizations that may help connect different parts of an innovation system (Klerkx and Leeuwis 2009)—may assist in developing shared innovation goals, in supporting the innovation network as it gets formed and in facilitating multidirectional stakeholder interaction (Klerkx et al. 2010). Such an approach has the potential to foster the kinds of collective action that will be required to achieve the long-term rural development and food and nutrition security objectives of CARICOM.

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Chapter 11
Fisheries Governance and Food Security in the Eastern Caribbean

Patrick McConney, Shelly-Ann Cox and Kemraj Parsram

Abstract Fisheries resources are of particular importance to the small island developing states of the Eastern Caribbean. There is an increasing demand for seafood to address food security and nutrition, to support coastal livelihoods and to contribute to sustainable development. The Caribbean Community developed a Regional Food and Nutrition Security Policy and a Common Fisheries Policy. These instruments, however, only make passing mention of fisheries and food security, respectively. There is little evidence of food security being integrated into fisheries governance. Yet, recent research has shown that resilience perspectives on fisheries governance in the Eastern Caribbean can be useful for obtaining ecosystem services, such as those that relate to food security, from social–ecological systems. This resilience takes into account global and regional environmental change, multiple levels of governance and degrees of adaptive capacity, matching the scales of social and ecological processes and managing social networks in the institutional arrangements for resource use and conservation. Building food security and resilience into fisheries governance requires the development of adaptive capacity, especially through social networks, with an emphasis on policies that enable fisherfolk self-organization.

Keywords Caribbean · Environment · Fisheries · Food security · Governance · Resilience

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11.1 Introduction

The Wider Caribbean Region, which encompasses the Caribbean Large Marine Ecosystem, is densely packed with nation-states and territories that are diverse in geography, culture, society, economy, politics and ecology. The region is one of the most complex in the world in terms of marine resource governance (Chakalall et al. 2007; Fanning et al. 2009; Mahon et al. 2010). The Eastern Caribbean is a sub-region of the Caribbean Large Marine Ecosystem that consists entirely of small island developing states (SIDS). Few marine boundaries have been negotiated, but there is considerable interaction of people and issues across jurisdictions due to proximity. Most fisheries resources in the sub-region are shared across marine jurisdictions and resource use regimes during their life histories. This contributes to social–ecological complexity (Fanning et al. 2011). Local, national, sub-regional, regional and international organisations engage in fisheries governance. The interplays among their formal mandates and actual operations add further layers of complexity to governance (Mahon et al. 2010). Current governance arrangements do not always integrate sufficiently, and at multiple levels, for related policies to achieve shared goals and objectives (Fanning et al. 2013).

A case in point is the contribution of small-scale marine capture fisheries to food security. The Caribbean Community (CARICOM) recently developed a Regional Food and Nutrition Security Policy (CARICOM 2010) as well as a draft Common Fisheries Policy (CRFM 2010). These related policies, however, only make brief mention of fisheries and food security, respectively. For example, the preamble of the fisheries policy recognises the 'importance of fisheries to social and economic development, food and nutrition security and the welfare of the peoples of the Caribbean' (CRFM 2010: 1). Yet, compared to other aspects of fisheries, food security is not well elaborated or integrated into fisheries governance. Similarly, the food security policy recognises fisheries as a sub-sector of agriculture, but thereafter offers little guidance on fisheries compared to crops and livestock. CARICOM food security and fisheries policies have been deficient in addressing global environmental change (Trotman et al. 2009). Both recent policies, however, acknowledge the need to adapt to global and regional environmental change. They encourage climate change adaptation, disaster risk reduction and people-centred ecosystem-based approaches. Spanning both the food and fisheries policies is the CARICOM strategic plan for 2015–2019 that includes resilience in its vision and as a core theme (CARICOM 2014). An immediate Caribbean challenge, therefore, is to better integrate food security into fisheries governance, both based on a resilience perspective.

The converging interest in resilience, food security and fisheries governance is timely. It provides an opportunity for the innovative integration that is required to nationally implement these regional policies. CARICOM countries must face the challenges of global environmental change (Ericksen et al. 2009), the uncertainties surrounding which are amplified when downscaled to regional-level fisheries at the geographic scale of SIDS (Nurse 2011). Devising means of integrating small-scale fisheries into sustainable food systems and food security is of considerable global interest (Nelson et al. 2013). Research in the Eastern Caribbean has shown that resilience perspectives can be useful for addressing the complex reality of sustaining ecosystem services, such as those related to food security, from dynamic fisheries social–ecological systems (Parsram and McConney 2011; McConney et al. 2011). This resilience takes into account multiple levels of governance, the varying degrees of adaptive capacity, the scales of social and ecological processes and social networks in the institutional arrangements for sustainable resource use (McConney and Parsram 2008). Building food security and resilience into fisheries governance requires the development of adaptive capacity through social networks and an emphasis on enabling fisherfolk self-organization. The next section outlines key concepts, the Eastern Caribbean context and methods of investigation. The results present brief case studies of building food security and resilience into fisheries governance, followed by a discussion of the findings.

11.2 Materials and Methods

Several key concepts guided our investigation of fisheries in the Eastern Caribbean. We set out the concepts, the fisheries context and the methods used in the case studies.

11.2.1 Concepts

We argue that for there to be successfully integrated and enabling policy for food fisheries, it is necessary to build both resilience and food security into fisheries governance. There is a reciprocal relationship in that good fisheries governance also enhances food security. Critical to resilience for food security and governance is adaptive capacity. Adaptive capacity is achieved in large part through social networks and the self-organization of resource users who contribute to food security and governance. Figure 11.1 offers a much-simplified illustration of these relationships that, in reality, are quite dynamic with multiple feedback loops, iterations and levels, plus external influences such as global and regional environmental change. The case studies address the relationships among these concepts to inform how to build food security and resilience into fisheries governance.

Resilience and its related subsidiary concepts have competing definitions (Berkes and Ross 2013). Central to the concept of resilience used here is the notion of a social–ecological system (SES). It emphasizes that social and ecological systems are inevitably linked, and that the delineation between the two systems is artificial and arbitrary (Berkes and Folke 1998). Resilience in SES is the capacity of the system to experience shocks while retaining essentially the same function, structure, feedbacks and therefore identity (Walker et al. 2006). Fisheries are complex adaptive SES, and the structure and nature of connections between the elements of a system (its networks) govern the dynamics and functions of complex adaptive systems.

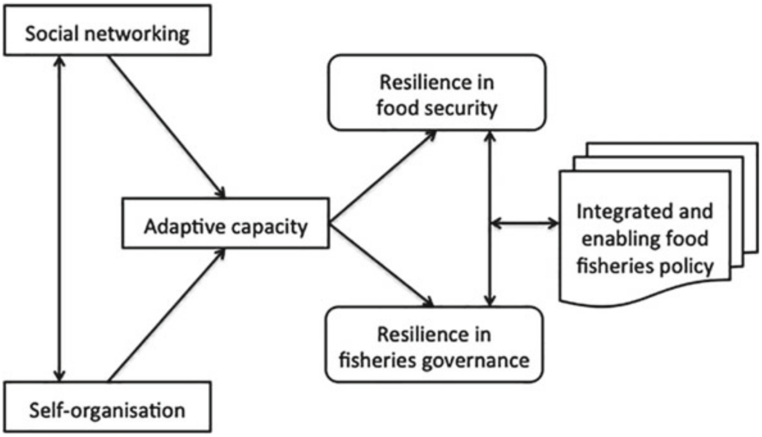

Fig. 11.1 Key concepts in building food security and resilience into fisheries governance for integrated policy

Critical functions include the abilities to self-organize and learn, which contribute to adaptive capacity (Mahon et al. 2008). Adaptive capacity is a multi-faceted contributor to resilience. It includes networks, self-organisation, learning and the ability to experiment with innovative solutions in social–ecological systems (Armitage 2005). In this research, our main interest is in social networks and self-organisation, and how the two enhance adaptive capacity that builds resilience. Other features such as wealth, knowledge, skills and physical assets also contribute to adaptive capacity (Armitage 2005) and resilience at different levels (Berkes and Ross 2013).

Social networks and self-organisation reinforce each other. Networks set out who relates to whom in what way, and how these ties enable the formal and informal institutions that guide and govern people's behavior (Mahon and McConney 2013). Ties are used to exchange resources such as goods, finance, information, services, social or emotional support, trust or influence (Bodin and Prell 2011). Networks partly determine system function and performance as well as social capital, power, self-organisation, adaptive capacity and other features of resilience (McConney et al. 2011). Self-organisation reflects minimal dependence on external inputs and is facilitated by collective action based upon networks. SES consists of multiple levels of networks that affect the way systems function across various scales and levels to cope with diverse external and internal disturbances (Berkes et al. 2003). This is evident in multi-level governance (Fanning et al. 2009). Governance is "the whole of public as well as private interactions taken to solve societal problems and create societal opportunities. It includes the formulation and application of principles guiding those interactions and care for institutions that enable them" (Kooiman et al. 2005: 17). Good governance that is resilient not only adheres to principles such as participation, inclusiveness, accountability, transparency and equity, but its governance structures and processes are adaptive. This is in distinct contrast to conventional legal-institutional rigidity and high levels of formality (McConney and Charles 2010).

Food security exists when "all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO 1996). Its three main components are food availability, access and utilisation. Food systems are SES, and within the value chains of small-scale fisheries in Eastern Caribbean SIDS the emphasis is on food production (fish harvest) and processing is minimal for most products purchased for household consumption. Food security, lies within the context of national and local level fisheries governance and needs to take into account environmental change, (McClanahan et al. 2015). Harvest and post-harvest sectors contribute more to food security if there is good fisheries governance (Trotman et al. 2009). Self-organised resource users become involved in national to local level co-management arrangements in which they share fisheries responsibility and authority with government agencies. In compact SIDS where co-management entails little decentralization, delegation or devolution to the community or local level, the emphasis is usually on the national level (Pomeroy et al. 2004). Co-managing fisheries for food security has become increasingly important due to worldwide fisheries depletions that may worsen with global environmental change (McClanahan et al. 2015). At the regional level, the vulnerabilities of SIDS make attention to food security, even more, pressing (Trotman et al. 2009) and quite critical for fisheries (Nurse 2011).

11.2.2 Context

The Eastern Caribbean islands from which the case studies are drawn are Barbados, Grenada, the Grenadines Islands, Saint Lucia, St. Kitts and Nevis, and Trinidad and Tobago. In all of them, the depletion of fisheries resources, coastal habitat degradation, pollution, threats from climate variability and change, fluctuating foreign exchange earnings, increasing unemployment and rising energy costs all contribute to the vulnerabilities typically associated with SIDS (Fanning et al. 2011). Most of their fishery resources are transboundary and shared. Species and species groups harvested include tunas, billfishes, sharks, dolphinfish, flying fish, snappers and other reef fish, sea urchins, lobster and conch. These fisheries vary in the status of resources and exploitation trends, the vessels and gear, and the approaches to governance for development and conservation. Fanning et al. (2011) note that island shelf, reef and inshore resources, including lobster and conch, are generally either fully exploited or over-exploited, as are most of the oceanic large pelagic stocks (e.g. tunas and billfishes). However, the status of the more regional pelagics (e.g. dolphinfish and blackfin tuna) is less certain. FAO (2014) states that in-depth analyses of Caribbean catch trends are generally hampered by the low quality of data and scarce fishery statistics.

The fisheries sector plays important roles in the economies of Eastern Caribbean countries. It contributes to culture, employment and food security, but these are not captured in its contribution of around 1% to the Gross Domestic Product (GDP) in many countries. Among the case study countries, the estimated employment in fisheries varies from 9,000 in Trinidad and Tobago (contributing 0.07% to GDP) to 600 in St. Kitts and Nevis (but contributing 2.39% to GDP) (CRFM 2012). The employment of women is important in post-harvest. The supply of most species is highly seasonal due either to natural patterns in abundance (e.g. flying fish) or to management measures (e.g. conch). Annual per capita fish consumption varies from a high of around 40 kg in Barbados to around 14 kg in Trinidad and Tobago. However, in most islands tourism demands a high level of seafood importation, and with the expansion of international seafood markets, some small-scale food fisheries have been displaced by fisheries directed towards export markets (CRFM 2012).

Key climate-related drivers in the Caribbean are a decrease in wet season rainfall, increased temperatures, sea-level rise and an increase in tropical cyclone activity, all of which increase the vulnerability of fisheries in these SIDS (FAO 2014). These concern both at-sea and on-land operations. Nurse (2011) states that investigation of the impacts of climate change and variability on Caribbean fisheries has lagged considerably behind other regions, and concludes that exposure and sensitivity to climate change threats are high in the Caribbean, while adaptive capacity in fisheries is low. All countries lack ecosystem-based fisheries policies or management plans, but there are recent initiatives to introduce the ecosystem approach to fisheries, climate change adaptation and disaster risk reduction into the repertoires of fisheries managers and resource users. Food security is still absent.

It is, however, recognised that small-scale fisheries, such as those of the Eastern Caribbean, are dynamic social–ecological systems requiring people-centred approaches (Berkes et al. 2001; Mahon et al. 2008). The Caribbean Community Common Fisheries Policy (CCCFP) provides the framework for this (CRFM 2010). The Regional Food and Nutrition Security Policy acknowledges the CCCFP and encourages the inclusion of food security, but provides no pathway for implementation linked to fisheries governance (CARICOM 2010). Implementation of the CARICOM strategic plan for 2015–2019 has not yet commenced, but it emphasizes resilience as a theme. In the context of transformation, which is systematically moving from an undesirable to a more desirable state (Olsson et al. 2004), this convergence of policies could create a window of opportunity (Fig. 11.2). However, preparatory steps are required to take full advantage of the opportunity. There are initiatives to address the knowledge and information deficiencies identified by Nurse (2011) and FAO (2014) as well as to use policy processes to create a shared vision (CRFM 2010). There is a logical sequence to the steps, but the process is non-linear and iterations are to be expected (e.g. between networking and knowledge mobilization). It is the step of strengthening social networks, self-organisation and adaptive capacity for building resilience (highlighted in Fig. 11.2) that is currently neglected and critically in need of attention. This step is addressed in the case studies.

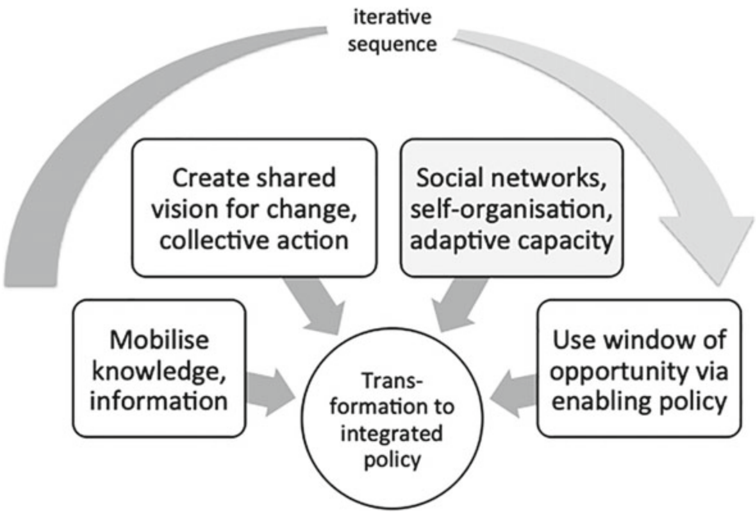

Fig. 11.2 The process of transformation to improved integrated policy

11.2.3 Cases

From 2007 to 2012, the research project on Marine Resource Governance in the Eastern Caribbean (MarGov project) focused on understanding governance related to small-scale fisheries and coastal management in the Eastern Caribbean. It used a conceptual framework derived from a complex adaptive system and social–ecological system perspectives (McConney and Parsram 2008), the relevant aspects of which were shown in Fig. 11.1. Insights into environmental change, resilience and food security were acquired in the investigations that focused on governance. Field research methods were interdisciplinary, with different suites of methods applied to better understand social networks, self-organisation and adaptive capacity (Table 11.1).

Table 11.1 Field research methods used in the case studies

Social networks	Self-organisation	Adaptive capacity
Social network analysis, semi-structured and informal interviews	Informal interviews	Semi-structured and informal interviews
Focus groups	Organisation workshops	Organisation workshops
Participant observation	–	Participant observation
Quantitative network analysis	Qualitative participatory analysis	Qualitative participatory analysis

Field methods comprised a mix of interviews, focus groups, participant observation and workshops. Social network analysis featured prominently. The remaining cases were generated mainly from sub-grants to in-country project collaborators (government agencies, co-management bodies and NGOs) to test some of the tools (e.g. social network analysis) and approaches (e.g. ecosystem approach to fisheries) in partnership with researchers. Workshops with the partner organisations generated most of the insights shared. Although all of the case studies covered the three aspects of interest, there was a clear precedence of focus in each such that the cases can be clustered into three groups based on their primary aspects (Table 11.2).

11.3 Results

Findings from the eight case studies are briefly reported, under the three primary investigative aspects, in terms of environmental change, food security, resilience and governance.

11.3.1 Social Networks

11.3.1.1 Multi-species Fisheries in Grenville, Grenada

It was found that fisherfolk were less concerned with environmental and ecological change (e.g. catches, seasonality, habitat) than with socio-economic issues (e.g. management livelihoods, marketing). They reported less predictable seasonality of both reef and pelagic fisheries. People structured livelihood strategies around seasonality and used ecological knowledge and marketing networks to cope with vulnerability. Increased variation in both the availability and abundance of fish both posed threats to food security. Rough seas reduced the number of fishing days of small boats with limited range even if fish were available. However, good fishing conditions and large catches quickly caused market gluts resulting in unprofitable price reduction and potential fish spoilage as fish storage was limited. Fishers used networks to manage their fishing operations and ex-vessel sales while fish vendors used their networks to either acquire scarce fish or rapidly move large catches. Vendors also used networks for collusion on low ex-vessel prices while maintaining high-profit margins for retail sales. Thus both the fish suppliers and consumers were at times disadvantaged, and there was high local dependence on the fish supply for household consumption. When the market was glutted, or vendors dropped price regardless of availability, the fishers would occasionally refuse to fish even under good conditions. Self-organization was more evident in the harvest sector through fishing cooperatives, but the adaptive capacity was low. The fishing cooperative and fisheries authority played minor roles in knowledge and marketing networks.

Table 11.2 Case studies clustered by primary aspect of investigation

Case studies noting geographic locations	Main features of each case study	Aspects of resilience focused upon to varying degrees in the case studies		
		Social networks	Self-organisation	Adaptive capacity
Multi-species fisheries in Grenville, Grenada	Network analysis of >100 fisherfolk; fish marketing; ecological knowledge; climate; cooperatives; national planning process	+++	+	++
Sea urchin fisheries in Barbados and Saint Lucia	Network analysis of >100 fisherfolk at 5 sites; climate; ecological knowledge; fisher work groups; livelihoods; planning process	+++	++	+
Caribbean Network of Fisherfolk Organisations	Interviews, workshops co-production with fisherfolk leaders; leadership style; network capacity; multi-level communication	+	+++	++
Fisherfolk organising in the Grenadines	Interviews, fisherfolk workshops; network capacity; communication; leadership	+	+++	++
Fisherfolk and government in Trinidad and Tobago	Institutional arrangements for governance; network adaptive capacity; conflict skills; leadership and advocacy; co-management	++	+	+++
Barbados Fisheries Advisory Committee	Legal mandate; policy influence; leadership; institutional reform; industry engagement	+	++	+++
Sea urchin fishery in Grenada	Collaborative fishery management; policy influence; livelihoods; institutional reform	+	++	+++
Ecosystem approach in St. Kitts and Nevis	Collaborative fishery management; vision; change management; institutional reform	+	++	+++

Key: +++ Primary aspect; ++ Secondary aspect; + Minor aspect

Factors enabling resilience included well-developed coping strategies for dealing with uncertainty from several sources. Tolerance of ecological and environmental uncertainty could confer resilience to climate change and variability in the harvest sector once the future ranges of climate events do not exceed experience to an overwhelming degree. Kinship and friendship informal social networks contribute to resilience in both harvest and post-harvest roles in food security. However, the factors that constrain overwhelm those that enable. The cooperative has little ability to influence fisheries. The negligible role that resource users play in managing the fisheries infrastructure is a constant source of conflict and a threat to food security. There is little evidence of institutional learning and adaptation in the governance arrangements. Fish marketing arrangements that frequently cause conflict and reduce trust between the harvest and post-harvest sectors mar the environment for developing adaptive capacity. The networks operate more for individual or group benefit than for building system resilience and their potential for contributing fully to food security and governance is limited.

11.3.1.2 Sea Urchin Fisheries in Barbados and Saint Lucia

The fisheries for the white sea urchin (*Tripneustes ventricosus*) in Barbados and Saint Lucia are of similar high socio-economic and cultural importance, but are managed under different governance arrangements (Cox and McConney 2015). These aim at adaptive co-management (Plummer and Armitage 2007). Urchin fisheries harvest high-value single species with significant culturally embedded demand and easy marketability. Urchin roe is highly nutritious. Urchins have been overfished in both countries, and the fisheries have remained closed for several years with very brief openings. Urchin populations experience natural large fluctuations due to environmental conditions, but the mechanisms are unclear as are the likely impacts of increasing global and regional environmental change. Despite their ecological similarity and vulnerability to environmental change, being sedentary coastal species, the sea urchin fisheries in Barbados and Saint Lucia are different due to geography, demography, culture and other factors that influence how resilience and food security factor into fisheries governance. The high cultural and financial value of sea urchin roe has caused urchin fisheries to be a high priority for adaptive co-management. However, weak state capacities to manage, and a high prevalence of illegal fishing, undermine the recovery of urchin populations despite multi-year closures in both countries. They also undermine food security.

Social networks among sea urchin divers relate to kinship, ecological knowledge, labour, trust, and fisheries management (Cox and McConney 2012). Despite networks and bio-physical conditions favouring community involvement, sea urchin fishery governance in Saint Lucia is more top-down than in Barbados (Cox 2016). The latter has encouraged fishers participation in all stages from surveys through data analysis to management advice (Mahon et al. 2003), and this has built capacity amongst a small, select group of fishers (Cox and McConney 2012). The illegal fishery has proven to be highly adaptive (e.g. night fishing with SCUBA to avoid surveillance) and exceptionally resilient supported by ‘rogue’ social networks. These networks are usually static and may include spouses who provide warning of the arrival of law enforcement officials (Cox 2016). The governance arrangements are not resilient, and they have been unable to adapt to resource and harvest patterns sufficient to keep the fisheries open and economically viable.

11.3.2 Self-organisation

11.3.2.1 Caribbean Network of Fisherfolk Organisations

The Caribbean Network of Fisherfolk Organisations (CNFO) was established in 2007 under a CRFM project to form, strengthen and network national level Fisherfolk organisations into a sustainable, self-organising regional entity. Sustainable fisheries livelihoods are the main concern of the CNFO. Fisherfolk leaders have included the ecosystem approach to fisheries in their organisational mission. They informally monitor environmental change and it has been a point of discussion at their workshops. Adaptation of fishing gear, safety at sea during extreme weather events, early warning systems, vessel design and changing species composition in catches are among topics discussed. The CNFO has been involved in regional events on climate change adaptation and disaster risk reduction. However, there is little evidence of food security being a major topic of discussion in any context other than livelihoods.

A highly participatory, bottom-up, collaborative planning process shaped the growth of the CNFO (McConney and Phillips 2011). Partly because of its very articulate and energetic fisherfolk leadership that had begun to influence policy at the regional level, it was considered a fisheries governance success (McIntosh et al. 2010). The CNFO transitioned from an informal network of fisherfolk leaders with no legal identity, formal structure, independent funding, constitution, strategic plan or communication strategy into a not-for-profit company with a board of directors in 2016 (McConney et al. 2016). Still, it continued to operate opportunistically in response to external funding and requests from regional and international fisheries organisations seeking fishing industry engagement in their activities. The façade of widely celebrated success hid deeper persistent organisational problems. Fisherfolk leadership was willing but not able to both maintain full-time fisheries livelihoods and maintain a vibrant regional network, so the latter suffered. The CNFO has become resilient in an undesirable position from a governance perspective and its capacity is too low for self-organisation. It is uniquely positioned for high potential in food security policy (McConney et al. 2017). However, it is not in a position to take significant action without external assistance.

11.3.2.2 Fisherfolk Organising in the Grenadines

In 2006, the Sustainable Grenadines Project brought fisherfolk together from throughout the transboundary Grenadines island chain to discuss key fisheries issues and identify potential solutions. An identified priority was to organise a stakeholder group for fisherfolk collaboration in the Grenadines. Nothing happened until 2009 when MarGov suggested a representative Grenadines fisherfolk network, essentially a downscaled version of the CNFO, to address shared issues surrounding fish marketing, fuel, communication, immigration, marine-protected areas, livelihoods and more. Environmental change was not a major issue, but food security was in terms of freedom of movement of fishers across the marine boundary, access to markets and fisheries infrastructure and several operational issues affecting fish supply. Households in the Grenadines are highly dependent on locally supplied seafood as well as on earnings from fisheries to purchase other food.

However, at present, there are no fully functional fisherfolk associations or cooperatives in the Grenadines, and only slowly emerging local leadership to form any. Most islands had bad experiences with cooperatives and there is a high level of mistrust amongst fisherfolk regarding the mismanagement of funds. Collaboration among Grenadines fishers, and between them and the main islands' Fisheries Divisions has been minimal. Self-organization in fashioning a network fisherfolk organization is taking a long time due to the need to rebuild trust among resource users and over-reliance on the state for leadership. The level of power accorded to state authorities constrains self-organization. An interesting adaptation to low capacity in this system was the decision to leave the fisherfolk network dormant until awakened by a crisis requiring collective action. This is not ideal. It demonstrates acceptance of a low level of adaptive capacity and hence resilience.

11.3.3 Adaptive Capacity

11.3.3.1 Fisherfolk and Government in Trinidad and Tobago

The Trinidad and Tobago government's Cabinet-appointed Monitoring and Advisory Committee (MAC) was a body that included government and fishing industry stakeholders. Trinidad and Tobago Unified Fisherfolk (TTUF) is the umbrella NGO that represents primary fisherfolk organisations in the country. Fisheries legislation did not prescribe formal stakeholder involvement in fisheries governance and not all governance structures enable self-organization and enhance adaptive capacity. However, these two bodies with overlapping memberships provided an informal institutional arrangement for collaboration (Sandy et al. 2011). The MAC was formed out of the need to resolve conflicts between trawlers and artisanal fishers along the north coast of Trinidad. A wide range of vessels of different size and range commonly practice shrimp trawling. The MAC advised the government on matters such as fishing regulations, gear specification and marine zoning for large- and small-scale fleets. All require attention to environmental change and are relevant to food security. Food security issues concern the amount and composition of catch available for local consumption versus export based on fleet size and operations, as well as target species versus by-catch and by-product (by-catch that is not discarded at sea).

Fishing industry MAC members established the TTUF partly because of dissatisfaction with decision-making in the MAC, and the need to form a national fisherfolk organisation for greater voice and influence on fisheries policy. The two organisations had an uneasy relationship. The actors who were dissatisfied had the capacity in their networks to form a new organisation but high levels of conflict pervaded both organisations. The MAC had such severe internal conflicts that it ceased functioning for a period. Low capacity for conflict management in the MAC and TTUF constrained fisheries governance and hence decision-making related to food security and other matters. Neither organisation was resilient. Training in conflict management, as part of building adaptive capacity, could have facilitated more resilient and effective in fisheries governance.

11.3.3.2 Barbados Fisheries Advisory Committee

Fisheries legislation in most CARICOM countries calls for a multi-stakeholder Fisheries Advisory Committee (FAC) to advise the minister on policy matters. This is, in effect, statutory national consultative co-management. Few countries have implemented this provision, but Barbados has since 1995. However, the FAC has struggled to influence policy (McConney et al. 2003). The FAC has been deeply involved in formulating successive fisheries management plans with attention to global and regional environmental change. This includes not only oceanographic conditions but also issues such as beach erosion that reduces fishing vessel haul-out space for repairs. The latter and similar operational matters affect food security by altering the amount and timing of fishing effort and the distribution of fish landings. The FAC often deliberates on seafood marketing and trade due to conflicts between seafood imports and local landings that are highly seasonal but unpredictable. Other food security issues have included seafood quality assurance and public health as the sale of low-quality local and imported seafood is a concern especially since customers attracted by low prices are often the poorest in society.

In 2008, the FAC attempted to strengthen its role in fisheries governance by engaging the fishing industry on current issues and good governance (inclusiveness, transparency, accountability, equity, consensus, efficiency, effectiveness, responsiveness, and rule of law). It became apparent, however, that the FAC lacked the capacity and leadership to self-organise and undertake its work in a more interactive approach. Gaps in capacity and leadership constrained the development of resilient governance arrangements. Dependence on the fisheries authority for support conflicted with the autonomy required for the FAC to render the best available policy advice from increased engagement with the fishing industry. Maintaining the FAC as a weak structure in national fisheries governance undermines the resilience of the industry contrary to the intention of the law.

11.3.3.3 Sea Urchin Fishery in Grenada

Depletion of the white sea urchin (*Tripneustes ventricosus*) around Grenada, caused mainly by commercial fishing for an export market, prompted the government to close the fishery in 1995 (Phillip and Isaac 2010). Since then there has been continuous illegal harvest resulting in only modest, occasional, temporary recoveries of urchin populations in years of exceptional recruitment. The population remains in a depleted state similar to the fisheries in Barbados and St. Lucia. However, a major difference is that in Grenada there is no system geared to open and close the fishery, depending on urchin abundance, based on a plan for collaborative management. As elsewhere, urchin populations fluctuate naturally in Grenada in response to environmental conditions in ways that are not well understood. Heavy recruitment can overgraze seagrass beds, so persistent fishery closure harms habitat as well as denying Grenadians a highly valued and nutritious food in years of plenty unless they engage in illegal harvest and purchase. As elsewhere, the illegal fishery is quite resilient.

Pressure from resource users for the fisheries authority to actively manage the fishery reached political levels in 2008. Partly in response to this pressure, the Fisheries Division initiated the participatory development of a sea urchin fisheries management plan. Grenada needs the adaptive capacity to transform the depleted and closed fishery into viability. Despite a stated desire to establish collaborative management, the fisheries authority was unable to operationalize this governance (Phillip and Isaac 2010). The enabling policy to provide the resources (financial, physical, human) for the fisheries authority to carry out its mandate as a co-management partner was absent. The required capacity could not be acquired through networking with the fishing industry since their capacity was also low (Nayar et al. 2009). Even with a new fisheries management plan, and substantial buy-in from most of the urchin fishers, the situation reverted to the status quo as there was no window of opportunity to sustain transformation.

11.3.3.4 Ecosystem Approach in St. Kitts and Nevis

Introducing an ecosystem approach to fisheries (EAF) involves changing marine resource governance; such as the way people make fisheries decisions for the benefit of society. EAF is a response to the failure of less comprehensive, conventional approaches to fisheries management to meet ecological, economic and social objectives. The Department of Marine Resources (DMR) of the Federation of St. Kitts and Nevis indicated interest in introducing EAF for its fisheries management planning (DMR 2011). EAF is incorporated into the Caribbean Community Common Fisheries Policy (CCCFP), as is food security, but no CARICOM country has introduced EAF or explicitly addressed food security in fisheries governance. Recent marine zoning provided information on environmental and ecological conditions and trends. The remaining priorities for transformation were visioning, developing adaptive capacity, and identifying EAF entry points (windows of opportunity). Consultations with stakeholders revealed that they had mainly ecological and economic perspectives on EAF. Fishers were concerned mainly about the fish stocks available for harvest and the markets to sustain and improve their livelihoods. NGOs were concerned mainly about the marine environment, while recreational users straddled the ecological and economic aspects.

Stakeholders said that to build resilience the critical requirements for adaptive capacity included awareness of EAF, stakeholder engagement, strengthening stakeholder organisations and promoting consumer involvement. The latter favours attention to food security. The conventional legal-institutional arrangements for fisheries governance were seen as too restrictive and not adaptive. Many suggested that implementation of EAF should be incremental rather than a large change. The immediate activation of a multi-stakeholder fisheries advisory committee, as provided for in legislation, was seen as a way to proceed, integrated across economic sectors. Participants also stressed the importance of proceeding with a change management plan. Stakeholders wanted to avoid partial or intermittent implementation that would frustrate stakeholders due to poor process.

11.3.4 Summary

Table 11.3 summarises the main findings from the above case studies and outlines recommended actions that are discussed collectively in the next section.

11.4 Discussion

Fisheries governance in the Caribbean Community is at a critical crossroads. Separate regional policies address food security (CARICOM 2010), fisheries governance (CRFM 2010) and resilience (CARICOM 2014), but lack guidance on how these policies are to be integrated and implemented at the national level in the context of global and regional environmental change. Nurse (2011) notes the absence of attention to climate change and variability in regional fisheries governance, but this situation is improving (Fanning et al. 2013). The same cannot be said for food security (Trotman et al. 2009). Directly or indirectly increasing the contribution of small-scale fisheries to food security is part of the global process of making fisheries governance more resilient (Béné et al. 2007). National fisheries governance typically addresses food security only indirectly as shown in the case studies, but there are opportunities to transform fisheries governance to better incorporate food security. In these cases, the weakest part of the process concerns social networks, self-organisation and adaptive capacity.

Resilience can be examined at several levels (Berkes and Ross 2013). Fisherfolk use social networks for coping with environmental and social change at the individual or enterprise level as evident in Grenada, Saint Lucia and Barbados. This individual

Table 11.3 Main findings from case studies and action recommended for the way forward

Case studies noting geographic locations	Main findings on resilience, food security and fisheries governance	Action to address resilience, food security and fisheries governance
Multi-species fisheries in Grenville, Grenada	• Networks are key in fishing, marketing • Vendors influence food price, supply • Governance arrangements are weak	Engage organised harvest and post-harvest fisherfolk in co-managing the fish market in order to stabilise seafood supply and prices, reducing wastage as part of comprehensive management
Sea urchin fisheries in Barbados and Saint Lucia	• Networks are strong for illegal harvest • Illegal harvest threatens food security • Adaptive co-management has potential	Using existing labour and knowledge networks, intensify the introduction of adaptive co-management, incentives for compliance and swift enforcement of equitable harvest rules agreed upon
Caribbean Network of Fisherfolk Organisations	• Low capacity limits self-organisation • High potential for food security role • Essential for regional level governance	Promote regional and national fisherfolk leadership training, strategic recruitment of support staff with financial skills and network CNFO to food security actors
Fisherfolk organising in the Grenadines	• Leadership constrains self-organisation • Critical role in local level food security • Too isolated for effective governance	Encourage Grenadines fisher leaders to network, collectively engage mainland authorities to improve infrastructure and systems for seafood, and join the CNFO
Fisherfolk and government in Trinidad and Tobago	• Conflicts cripple resilience building • High potential for food security role • Conflict management critically needed	Develop capacity in managing conflicts, policy influence and awareness of food security policy among both government authorities and fishing industry actors
Barbados Fisheries Advisory Committee	• Unable to adapt to increase influence • Key to improving food security policy • Statutory duty to improve functioning	Provide FAC with resources to engage the fishing industry and advise directly on policy including food security, with reduced dependence on the fisheries authority for most operational support
Sea urchin fishery in Grenada	• Transformation could not be completed • Important for national food security • Enabling policy sustainable change	Strengthen the policy and legal basis for collaborative management, enabling the fisheries authority to perform; increase fisherfolk and consumers awareness of food security in fisheries management
Ecosystem approach in St. Kitts and Nevis	• High potential to improve resilience • Food security needs to be addressed • Amenable to EAF governance reform	Formulate a participatory process for incrementally introducing EAF within the context of new legal-institutional arrangements for multi-stakeholder engagement, including on food security

or enterprise level resilience is often not scaled up to the local or national level for positive contributions to food security and fisheries governance. On the contrary, these networks can be harmful and only benefit a few. In Grenville, post-harvest networks at times constrain fish landings and inflate consumer prices, while in Saint Lucia and Barbados networks feature in illegal sea urchin harvest and marketing to the detriment of long-term stock recovery and a more sustainable supply of seafood for everyone. We advocate using network analysis to identify leaders and change agents in these networks (also see Bodin and Prell 2011) to redirect their efforts to strengthen collective action through cooperatives or other industry groups that could collaborate in managing fisheries infrastructure and resources. This, as integrated and enabling policy, would strengthen fisheries governance and stabilise affordable, legal seafood supplies. At sites like Grenville, such changes and the removal of constraints could also herald the introduction of small-scale fishery local food movements (Nelson et al. 2013), making further positive use of fisherfolk social networks in food security.

Self-organisation applies in these cases particularly to the struggling fisherfolk organisations such as the regional CNFO and the transboundary network organisation in the Grenadines. Given that most fisheries resources in the Eastern Caribbean are shared, these organisations offer unique opportunities, if strengthened, to assist in matching the geographic scale of the harvest to ecological management units, with consequent benefits for food security. One can envisage policy enabling coordinated efforts across maritime jurisdictions at the resource user level for both conservation and exploitation to ensure more sustainable and stable seafood supplies. The CNFO is already a part of the CRFM governance structure. With the strengthening of leadership and sustainable financing it could become a resilient and influential actor, as could the Grenadines network at a lower level. A policy initiative along these lines would enhance the 'livelihood landscapes' of the fisherfolk, improving their adaptive capacity (McClanahan et al. 2015). These connections have not yet been considered under policy.

Adaptive capacity encompasses more than networks and self-organisation. In these cases, the capacity to adapt for more resilient fisheries governance structures and arrangements that could contribute to food security required skills in conflict management, resources to provide policy advice, enabling policy for operational resources and revised legal-institutional arrangements among others. The actors in the four cases were involved or intending to be involved in national level collaborative management with relevance to food security but the latter was not a priority. The governance reforms recommended here (Table 11.3) provide the opportunity to increase awareness of their roles in food security, which in turn will strengthen their arguments for further developing adaptive capacity and resilience. The Caribbean is dependent on fisheries resources for food security, livelihoods and other ecosystem services that are highly vulnerable to climate impacts. Nurse (2011) indicates that global climate models, even if downscaled to the regional level, will still leave more questions than answers for fisheries in Caribbean SIDS. It is essential therefore that attention focus less on prediction and more on adaptation and resilience. Food security offers new opportunities to focus on the integration of enabling policy coupled with reformed fisheries governance to improve fisheries social–ecological resilience in the CARICOM region.

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Chapter 12
Food Security and Livelihood Vulnerability to Climate Change in Trinidad and Tobago

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Abstract Household-level food security in coastal wetland communities in Trinidad and Tobago experience increasing challenges in the face of climatic change. These communities rely heavily on natural resources and agriculture for their livelihoods. Household data were collected from 138 households in the Nariva and Caroni communities focusing on gender and socio-demographic structure, livelihood strategies and social networks; exposure to climate change and climate-induced extreme weather events, such as floods and droughts; and access to services and infrastructure. Using regression analyses, the influences of adaptive capacity to climate change on food security were analysed by gender, household and communities. Household socio-demographic structure and livelihood strategies were strongly related to food security and food security was reduced in the face of climate variability and disaster. Household social networks households had no significant influence. These conclusions offer directions for community and national planners and policy makers in Trinidad and in other similar country circumstances where climate change is significant.

Keywords Food security · Vulnerability · Climate change · Adaptation · Trinidad and Tobago

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12.1 Introduction

The Intergovernmental Panel on Climate Change (IPCC) defines climate change vulnerability as a function of a system's exposure and sensitivity to climatic stimuli and its capacity to adapt to the effects (IPCC 2007). At household level, vulnerability assessment provides an explicit indication of the capabilities, assets and activities required for achieving sustainable livelihoods. Key climate change vulnerabilities and impacts in small Caribbean islands, identified by the IPCC, include sea-level rise, increased intensity of cyclones, increased temperature and changing rainfall patterns (Robinson 2018). Climate resilience, on the other hand, refers to the capacity of a socio-ecological system to absorb stresses and maintain functions in the face of climate change and adapt, reorganize and evolve to be better prepared for future climate change impacts (Nelson et al. 2007). A climate-change-resilient household is, therefore, able to adapt, cope and recover from shocks, and maintain or enhance its capabilities and assets while not undermining the natural resources it depends on (Adger 2000; Shah et al. 2013). Household resilience must be built across multiple asset types (social, financial, human and physical) to withstand weather variability and attendant risks, shocks and stresses (Prowse and Scott 2008; Shah et al. 2013). Rural households, in particular, face severe challenges given their limited capital and assets, increased risk of exposure, restricted ability to cope and lack of access to resources such as food, water, shelter, health care and transportation (Kelly and Adger 2000; Dulal and Shah 2014).

Food security is a strong indicator of overall household vulnerability to climate change since it reflects the capacity to absorb contingencies including loss of earnings (purchasing power), sickness or unemployment (Potter 1999; Adger 1999). The Food and Agriculture Organization (FAO) defines household food security as a 'situation that exists when households, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life' (FAO 1996). This definition comprises four key dimensions of food supplies: availability, stability, access and utilization. Availability refers to the overall ability of the household to meet food demand. Stability relates to households that are at high risk of temporarily or permanently losing access to the resources needed to consume adequate food because of income shocks, lack of adequate 'reserves' for adequate consumption, or both. Access depends on household command over local legal, political, economic and social arrangements. Utilization encompasses such factors as food safety and nutritional quality across the food chain. Climate changes each of these aspects of food security in many complex ways (Schmidhuber and Tubiello 2007).

This chapter explores the relationships between food security and climate change in the context of rural households in the small island developing state of Trinidad and Tobago, part of the region that the IPCC categorized as a global 'hot spot'. Growing evidence suggests that Caribbean islands are already experiencing diminished food security through agricultural losses and ecosystem degradation caused by climate change (AOSIS 2009; Fischer et al. 2005), which are also evident in the form of high rate of diabetes and heart diseases (Lowitt et al. 2015). Rural communities like those in Trinidad and Tobago often experience weaker ties to centralized resilience-strengthening institutions, infrastructure and systems that impact their climate change coping mechanisms (Shah 2011; Gregory et al. 2005). Therefore, a polycentric approach to resilience is required (Ostrom 2010). Climate experts in the Caribbean recognize that a disruption of the current political and socio-economic systems, away from the overwhelmingly top-down approach, is needed to build climate change resilience (Saxena et al. 2018; Middelbeek et al. 2014; Robinson 2018). A decentralized governance structure that incorporates inputs across stakeholders and not the mere addition of more social actors is required (Lowitt et al. 2015). Additionally, the dependence of rural communities on prevailing ecological services for livelihoods in farming, hunting, fishing and nature-based tourism can directly impact on household-level food security (Dolan and Walker 2006).

This study adds to the few empirically driven studies on household food security in relation to climate change vulnerability in SIDS. While the quality and quantity of empirically based climate change vulnerability studies continue to grow in the social sciences (e.g. Barnes et al. 2013) the majority depend on secondary data sources that cannot capture fine-grained, context-specific data (Preston et al. 2011). This study offers insights from primary data. The next section explains the research framework from which we propose testable hypotheses about the relationship between climate change and household food security, and the influence of adaptive capacity building factors such as household socio-demographic structure, livelihood strategies and social networks. The methodology is outlined and results of the regression analysis used to test the hypotheses are then presented and the main findings discussed. We conclude by highlighting some of the new and important insights of the study as well as their implications for policy and practice.

12.2 Background and Conceptual Framework: Relating Climate Change Exposure to Household Food Security

Household food security can be characterized as a function of household exposure to climate change, its capacity to adapt to this (adverse) change and its sensitivity to change (Preston et al. 2011). This corresponds to the IPCC notion of ‘end-point’ risk, ultimately food security. The term ‘adaptive capacity’ refers to ‘the potential, capability, or ability of a system to adapt to climate change stimuli or their effects of impacts’ (IPCC 2001). At household level, it implies that in principle, factors contributing to household adaptive capacity have the potential to reduce climate-change-induced damages and/or increase household benefits. The relationships between exposure to climatic change, household structures, networking ability and livelihood strategies (i.e. drivers of adaptive capacity); and community sensitivity factors such as access to health care and water supplies, influence household food security (Hahn et al. 2009; Shah et al. 2013).

Caribbean island vulnerability is vividly characterized by the devastation of entire economies by powerful hurricanes and storms in regions such as Hurricane Maria (2017) in Puerto Rico and the Virgin Islands. The region also experienced sequences of significant climate events, including impacts from the 1997–1998 El Nino Southern Oscillation (ENSO) event, the highest sea surface temperatures on record (2005), and severe, wide-spread drought (2009–2010). Vulnerability to climate change extends beyond hurricane impacts. Both rainfall and temperature are important factors affecting crop yields and agricultural productivity, which disrupt rural incomes and nutrition patterns. Drought can also impact mental health by introducing uncertainty and unpredictability to the source of income and livelihood of households (Sam et al. 2018). Agricultural production in the Caribbean will probably continue to be disrupted by climate change.

Added to the region's challenges from climate-induced extreme weather are the limitations of relief efforts in rural communities due to inaccessibility and poor national planning to provide foods, medicine and potable water after extreme events. Food systems require complex social, economic and biophysical adjustments to adjust to crises and achieve resilience, based on and reflecting assessments of risk and vulnerability to climate change, especially for poor households with limited access to capital assets. The need for adaptation may vary quite significantly, depending on household access to endowments and entitlements, from a particular improvement, for example, in access to drought-resistant crop varieties to substantial changes in farm managements and livelihood strategies. Systemic changes may be required by farmers, retailers and intermediaries in the food chain, and in the financial sector and government institutions dealing with social protection and welfare administration. Given the impact climate change and climate-induced extreme weather events have on food security we suggest that (H1) rural households experiencing more climate change exposure (rainfall and temperature variability) are more likely to have less food security.

12.3 Building Adaptive Capacity Through Socio-demographic Structures, Livelihood Strategies and Social Networks

Climate change adaptations are systematic changes that better equip households to deal with problematic exposures and sensitivities. They are manifestations of adaptive capacity that represent ways of reducing vulnerability (Smit and Wandel 2006). Household socio-demographic characteristics, types of livelihood strategies pursued and social networking ability may impact adaptive capacity in general and food security more specifically. Various characteristics are relevant to food security such as the dependency ratio of the household. Additional people in households increase the burden on food resources, especially in the aftermath of extreme events. Similarly, young children and the ailing elderly place additional burdens on food resources because they require special nutritional needs. The burden of caregiving, which typically falls on women, takes household contributors away from field work, marketing or other food gathering-related livelihood activities—further reducing food security (Hahn et al. 2009). In addition, women in most SIDS are responsible for selection and preparation of food and feeding the children (Sam et al. 2018). Structural constraints result in households headed by less educated adults having difficulty adjusting traditional practices to cope with climate change (Zezza and Tasciotti 2010). To understand the relationship between household socio-demographics and food security, as well as the potential additional influence of climate change, we suggest that (H2) households with 'resilient' socio-demographic profiles are more likely to have greater food security. Further (H2b) climate change exposure will moderate the relationship between socio-demographic profile and food security of households in such a way that greater climate change exposure will be more likely to lead to less food security.

Household livelihood strategies are crucial, in terms of household income streams and the vulnerability associated with the volume, flow and sources of this income. Household vulnerability is reduced when more than one household member earns an income, especially when they work in different sectors, beyond agriculture and fishing, and in different areas. Households with diversified livelihood strategies are likely to be more resilient than those in climate-sensitive sectors, such as agriculture, being less affected by stresses, more flexible and with greater ability to buffer climate shocks and achieve positive outcomes (Osbahr et al. 2008; Parry et al. 2008). Therefore, we suggest that (H3) households with diversified livelihood strategies are more likely to have greater food security, and that (H3b) climate change exposure will moderate the relationship between livelihood strategies and food security of households so that greater climate change exposure will be more likely to lead to reduced food security.

Livelihood diversification alone may be insufficient in buffering climate shocks and ensuring food security. In communities where communal pooling is important to meet growing and harvest seasons, households pool social capital and build networks to achieve greater chances of securing food security, reduce individual household risks and contributing to climate change adaptation (Agrawal and Perrin 2009). Strong social networks support both individuals and collective initiatives, enabling enhanced resilience, well documented in Africa and Asia, where they are involved in improving food security and responding to crises with welfare activities and development projects (e.g. Chen et al. 2014; Deressa et al. 2009; Hillig and Connell 2018). Therefore, we suggest that (H4) households with more active engagement in social networks are more likely to have greater food security, and (H4b) climate change exposure will moderate the relationship between social networks and food security of households so that greater climate change exposure will be more likely to lead to reduced food security.

12.3.1 The Case Study Site: Trinidad and Tobago

Trinidad and Tobago is highly susceptible to climate change as temperature and sea-level rise impacts soil quality and increases the occurrence of pest and disease outbreaks (Shik et al. 2018). Climate events have a tremendous impact on agricultural production, since a third of all agricultural land is vulnerable to flooding, while drought and fire, as in 2010, may also affect harvests. With an expected decrease in rainfall and an increase in adverse climate events, agricultural practices of highly vulnerable rural communities are likely to be greatly affected (Eitzinger et al. 2015). Inflation in the islands is much affected by food price increases as a result of fluctuating local production and global food price inflation (Thomas 2012). Many communities in the country are thus poorly placed to respond to climate change.

We focus on two wetland communities in the Caroni National Bird Sanctuary and the Nariva Swamp, which are both well-known international Ramsar sites. The Caroni Swamp encompasses the Caroni National Bird Sanctuary on the Gulf of Paria on Trinidad's west coast. It is the largest mangrove swamp in Trinidad, containing 60% of the country's mangrove and drains the catchment area of a significant portion of the northwest and central Trinidad. It is ecologically diverse, consisting of marshes, mangroves, brackish and saline lagoons and tidal mudflats in close proximity. The swamp has been modified by attempted reclamation, and there is seasonal cultivation on the landward fringe. Surrounding villages still heavily depend on the swamp both within and around the park boundaries for fishing, crab catching, oyster harvesting and ecotourism. The swamp is surrounded by agricultural land, and commercial rice farming continues to create negative environmental impacts through chemical/fertilizer runoff and land clearing activities. Sugarcane is cultivated on a commercial scale for sugar and rum production but vegetables and fruits are the main subsistence foods. Because the Caroni Swamp is a low-income community, there is relatively little dependence on imported food but due to its close proximity to nearby cities, it has access to imported food sold in supermarkets.

Although just 15 kilometres from the nation's capital, and adjacent to the thriving Borough of Chaguanas, about two of every five households are below the poverty line. The community is primarily of East Indian origin, with joint and extended family households the norm. Historically, the community has hosted one of the island's most revered Hindu cremation sites, and various government regimes have targeted it for development as a major national cultural tourism site and landmark. Its rural nature is disappearing with increased infrastructure development, including fishing landing and dock upgrades, drainage and revetments to reduce seasonal flooding, and desilting of the Caroni River and its tributaries.

The Nariva Swamp, at seven thousand hectares, is the largest wetland in Trinidad and Tobago and receives most of its water from rivers in the Central Mountain Range. Nariva Swamp offers recreation in the form of hunting, fishing and ecotourism. Furthermore, the swamp supports subsistence agricultural production, including rice and vegetable farming, and root crops like yam, dasheen and taro, and provides a source of freshwater fish and conchs. It supports a diverse population of flora and fauna, with various distinct types of vegetation ranging from tropical forest to open waters. In 1992, it was listed as a Wetland of International Importance under the Ramsar Convention and, in 2006 it became an Environmental-Sensitive Area under the Environmental Management Act of Trinidad and Tobago. The Nariva community is also a low-income community but, unlike the Caroni community, neighbouring cities are at some distance, making trips to supermarkets to get imported food rare occurrences.

Socially, most households have been in the area for many generations, often with multiple extended families on the same plots; yet many do not have legal ownership of the land, while increasing agricultural production has caused serious environmental damage to the surrounding swamp. Ongoing tensions revolve around land tenure, as less than half of households have secure land ownership, while others have short-term lease agreements or occupy land illegally. Conflict over resources also continues among commercial rice farmers, family small-scale farmers and conservationists, all of whom have been political 'footballs' for more than two decades. Significant migration has taken youths to the nearest towns, such as Rio Claro, for job opportunities and to south Trinidad to seek work in the more lucrative oilfield. Amidst these issues, there is increasing international recognition of Nariva Swamp as an ecologically important site, coupled with growing enthusiasm for ecotourism development, which has led to stronger village organization and social cohesion.

With climate change, the dependency of both communities on local food production is at risk. Although, Trinidad is less likely to be at risk to hurricanes than many Caribbean islands (Pielke et al. 2003; Eitzinger et al. 2015), those that do impact the island are getting more intense. Sea-level rise and storm surges are being experienced in both communities, although more evident in Nariva Swamp on the eastern Atlantic Ocean coast compared to Caroni Swamp located in a shallow bay. Sea-level rise has led to the destruction of beaches and road infrastructure in recent years in the Nariva community. Caroni Swamp, on the other hand, has experienced reduced food production by an increased occurrence of oil spills, due to the heavy industrial activity of the oil and gas industry in the area, and pesticide runoff (Al-Tahir and Baban 2005). Both communities, but especially Caroni, are expected to have decreasing suitability for agricultural production because of climate change (Eitzinger et al. 2015). While both communities are far below national nutritional standards due to their socio-economic status, Caroni is better off than Nariva, since its aquatic and agricultural production is much more diverse. The majority of the Caroni people are of Indian ancestry and therefore have elements of traditional Indian food in their food choices (more vegetables and curried food but less red meat) while the Nariva community has more African cultural components which influences their food choices (for plantain and root crops like yam and cassava).

12.3.2 Survey Design and Operation

We designed a survey questionnaire instrument to collect primary household-level data on multiple food security, adaptive capacity and natural disaster indicators, based on previous surveys (Shah et al. 2013) and developed through meetings with local stakeholders (i.e. community group leaders, local academics and officers of the ministries of agriculture, community development and environment). We selected villages close to each wetland: Cacandee on the southern edge of Caroni and Cascadoux/Kernahan in the southern part of the Nariva wetlands. An a priori analysis suggested that a minimum sample size of 134 households was required. Cacandee consisted of almost 400 households so that a minimum sample size of 78 households was required. This village consists of a ribbon development that runs north to south along a main road, with several less dense branch roads extending east to west. A systematic sampling approach was adopted, along each road until the sample size was achieved. Kernahan and Cascadoux were effectively a single community, with village centres about 4 km apart, with increasing ribbon development between, and without distinct socio-economic differences (Baptiste and Nordenstam 2009). Kernahan and Cascadoux had 91 and 42 households, respectively, so the sample consisted of 38 households from Kernahan and 18 from Cascadoux. Surveys were administered on weekends since household heads were more likely to be at home rather than during weekdays when they were likely to be in the fields, fishing, at market or working in towns. Cultural expectations dictated that males be interviewed as the head of the household.

12.3.3 Data Analysis

Food security was measured by five indicator questions that were subjected to factor analysis and scale reliability checks, and a household Food Security Index was averaged from the combined standardized scores. Four household-level explanatory variable indices were created: a Socio-Demographic Index (comprising of five indicator questions), a Livelihood Strategy Index (four indicator questions); a Social Networks Index (three indicator questions) and a Climatic Exposure Index (five indicator questions). Two additional control variable indices—a Health Security Index (four indicators) and a Water Security Index (four indicators)—were also constructed. The index for each household was averaged from the combined standardized scores of the respective indicator questions.

Six ordinary least squares (OLS) regression models were estimated to test the hypotheses. One main effects model was estimated to account for the relationship between the household Food Security Index and the explanatory adaptive capacity indices. Four main effects models were estimated to account for the relationship between the household Food Security Index and the indicators of each of the explanatory adaptive capacity indices. Lastly, one interaction model was estimated to account for the moderating effects of the Climate Exposure Index on the relationship between each explanatory Adaptive Capacity Index and Food Security. Three control variables were included in all models: household location (either Nariva or Caroni), Water Security Index and Health Security Index. Access to water resources for the household, crops and livestock may impact overall food security; access to health care and precautionary measures may impact the ability of household members to undertake activities related to food security. T tests presented in Table 12.1 suggest some location-based differences in water security indicators.

Regression models (Tables 12.2, 12.3, 12.4, 12.5) relate to the hypotheses developed earlier. Model 1A (Table 12.2) supports hypothesis 1, that with an increase in climate change exposure, food security decreases; hypothesis 2, that with more resilient socio-demographic profiles, food security improves; and hypothesis 3, that diversified livelihood strategies are positively related to better food security. Although a positive relationship was found between social networks and food security, lack of statistical significance made the results inconclusive.

Model 1B (Table 12.2) supports hypotheses 2B, that although there is a positive relationship between socio-demographic profile of households and level of food security, climate change exposure moderates this relationship to reduce the level of food security accrued through more resilient socio-demographic profiles, and 3B, that although there is a positive relationship between household livelihood strategies and food security, climate change exposure moderates this to reduce the level of food security accrued through diversified livelihood strategies. Hypothesis 4B remains inconclusive, owing to the lack of statistical significance. Of the three control variables included in all the models, the results in models 1A and 1B suggest that food security of households increase when there is more household water security. No statistically significant relationship was found between household food security, location and health security. Models 2A, 3A, 4A and 5A explore the relationships between the indicators that comprise each sub-index and food security. Positive relationships exist between households where the head of household completed school (model 2B), the household received government assistance (model 4A), and the level of food security. Negative relationships occurred between households with dependents who need full-time care (model 2A), households without members earning income outside the community (model 3A), the number of floods/droughts, households experiencing injury and death, deviation in average precipitation (model 5A), and the level of household food security.

These findings indicate that food security in rural, wetland households is already vulnerable to climate change because of weak adaptive capacities, including socio-demographic profiles, livelihood strategies and social networks. Meanwhile the two communities are now on the frontlines of extreme weather events such as flooding, and several household factors which would have otherwise contributed a measure of resilience (by increasing food security) are weakened in the face of climatic change. This is also true even when factors such as household location and access to infrastructure and services are accounted for.

Overall food security is predicted to decrease by 0.24 index points for every point increase in climatic variability and weather-related loss (Table 12.2: Climatic Change

Table 12.1 Independent t tests of means for Caroni and Nariva

Indices and indicators	t test: t values and significance (df = 132)
Food security index	
% Households primarily dependent on self-farmed food	1.467
Average crop diversity index	0.68
% Households that do not sell/barter crops for other food supplies	1.782
% Households depending significantly on fishing/hunting for food	−1.034
Socio-demographic index	
Dependency ratio	1.32
% of female-headed households	0.98
% Household heads did not attend school	1.13*
% Households with members needing dependent care	2.05
Livelihood strategies index	
% Household without members working outside the community	−0.882
% Households main income dependent on agriculture/fishing/hunting	0.209
Avg. agricultural livelihood diversity index	3.901*
% Households without non-agricultural livelihood income contribution	−1.556
Social networks index	
Avg. receive: give ratio	0.521
Avg. borrow: lend ratio	−1.012
% Households who have gone to government for assistance in the past 12 months	2.472*
Water security index	
% Households without pipe borne water	−8.022**
% Households utilizing natural water systems	4.915**
Avg. days without water supply per month	3.066*
Avg. days supply stored per households	7.12
Health security index	
Avg. time to health facility	−4.111**
% of households with members suffering chronic illness	−0.246
% Households where member missed work/school in the past 2 weeks due to illness	−0.85
Avg. dengue exposure prevention index	0.923

(continued)

Table 12.1 (continued)

Indices and indicators	t test: t values and significance (df = 132)
Climatic change index	
Average number of floods/droughts in the past 3 years	2.793
% Households with losses to physical assets (house/machinery) due to flooding	0.18
% Households with injury or death from natural disasters in the past 3 years	1.569*
Mean standard deviation of monthly avg. of avg. max. daily temperature (1999–2005)	6.45
Mean std. deviation of monthly avg. of avg. minimum daily temperature (1999–2005)	1.13
Mean std. deviation of monthly avg. precipitation	2.63*

t tests conducted using actual indicator values
Two-tailed significance levels: ***p \ 0.001; **p \ 0.01; *p \ 0.05

Index). Climate change impacts are more complex than a string of discrete weather occurrences such as droughts that occur in the 'dry season' or floods in the 'rainy season,' and flooding was regarded as more damaging than periodic droughts. This is not surprising when, for instance, households reported between seven and 10 flooding incidents in the past 3 years and about a quarter of all households lost their shelter and/or machinery/equipment from weather disasters in the same period. Although Nariva households reported significantly higher levels of household injuries and deaths due to weather incidents, and its rainfall was markedly higher, there was no statistically significant difference in the overall six-indicator Climatic Change Index between the two communities. Nonetheless, the most significant climatic change indicators were rainfall, the number of flooding incidents and the numbers of injuries and deaths from disasters.

One factor directly influencing household food security was the socio-demographic profile of the household, as measured by the Socio-Demographic Index. Food security decreases by 0.49 index points for every point increase in strength of household socio-demographic profile (Table 12.2). The factors that contribute most to less resilient household profiles are the heads of household without primary school-level education (one in five in Caroni and one in three in Nariva) and the number of households with members who need full-time dependent care (about one in four of all households), including the elderly and infants. With the exception of household education level, there was no statistically significant difference in the four other indicators or the overall socio-demographic profile between Nariva and Caroni households (Table 12.1).

While some research in other contexts has suggested increased household resilience in female-headed households (e.g. Demetriades and Esplen 2008; Below et al. 2012) others have pointed to the contrary (e.g. Haque et al. 2012; Kartiki 2011;

Table 12.2 Food security, climatic change and adaption factors, ordinary least squares regression

	Model 1A (main)	Model 1B (main + interactions)
Constant	0.52 (3.22)***	0.59 (2.98)***
Location[a]	0.32 (0.21)	0.45 (0.44)
Health security index[b]	0.23 (1.12)	0.31 (0.97)
Water security index[c]	0.31 (1.16)*	0.30 (1.01)*
Socio-Demographic Index	0.49 (0.89)*	0.45 (1.11)*
Livelihood index	0.55 (1.01)**	0.53 (0.89)**
Social network index	0.11 (0.08)	0.12 (−0.05)
Climatic index	−0.24 (−0.21)*	−0.22 (−0.56)*
Socio-demographic. 9 climatic		0.19 (0.88)*
Livelihood 9 climatic		0.21 (0.78)*
Social network. 9 climatic		0.05 (0.94)
N	134	134
F value	6.23***	7.88***
R^2	0.36	0.39
Adj.-R^2	0.31	0.30

t values in parentheses
[a,b,c]Control variables
****p* \ 0.001; ***p* \ 0.01; **p* \ 0.05

Sam et al. 2017, 2018; Boukary et al. 2016). Where female-headed households have been resilient to the effects of climate change, they have adapted by implementing sustainable agricultural practices (like cultivating drought and flood-resistant crops), a knowledge gained from experience. By contrast, where female-headed households have become more vulnerable, it was due to a high female illiteracy level, low access to social capital coupled with a high dependency ratio after male outmigration to urban areas, and cultural expectations that requires households to be headed by men. In Trinidad, however we found no statistically significant difference with regards to gender. When household socio-demographic profile interacts with climatic change, the level of household food security is predicted to increase, but only negligibly

Table 12.3 Food security and socio-demographics, ordinary least squares regression

Model 2A	
Constant	0.463 (4.72)***
Location[a]	0.56 (2.98)
Health Security index[b]	0.28 (−0.04)
Water Security index[c]	0.27 (1.10)*
Dependency ratio	−0.79 (−1.85)
Heads completed school	0.26 (1.66)**
Dependents needing care	−0.17 (−1.32)*
N	134
F value	3.35***
R^2	0.32
Adj.-R^2	0.29

t values in parentheses
[a,b,c]Control variables
***p \ 0.001; **p \ 0.01; *p \ 0.05

Table 12.4 Food security and livelihood strategies, ordinary least squares regression

Model 3A	
Constant	1.86 (4.55)***
Location[a]	0.68 (1.79)
Health security index[b]	0.24 (1.15)*
Water security index[c]	0.33 (0.32)
Households with no member working outside	−0.29 (−1.76)**
Households mainly agriculture dependent	0.45 (3.59)
Agric. Diversity	0.90 (1.66)
Households without non-agricultural income	−0.11 (−1.92)
N	134
F value	4.28***
R^2	0.28
Adj.-R^2	0.27

t values in parentheses
[a,b,c]Control variables
***p \ 0.001; **p \ 0.01; *p \ 0.05

Table 12.5 Food security and social networks, ordinary least squares regression

Model 4A	
Constant	2.04 (1.75)***
Location[a]	0.15 (0.34)
Health security index[b]	0.11 (0.89)
Water security index[c]	0.23 (1.02)
Avg. received: give ratio	0.78 (1.93)
Avg. borrow: lend ratio	−0.79 (−1.4)
Households with government assistance	0.15 (0.93)
N	134
F value	1.82**
R^2	0.27
Adj.-R^2	0.25

t values in parentheses
[a,b,c]Control variables
***p \ 0.001; **p \ 0.01; *p \ 0.05

(Model 1B, Table 12.2). Thus, the hypothesis that gains in household food security are made in households with a more resilient socio-demographic profile effectively disappears in the face of climatic variability and weather-related losses (Table 12.6).

The other main adaptive capacity factor influencing household food security is livelihood strategies. Household food security can be expected to increase by 0.55 index points for every one point that household livelihood strategy is strengthened (Table 12.2). When household livelihood strategies interact with climatic change, the level of household food security increased by 0.21 index points (Model 1B, Table 12.2). Consequently, the predicted gains in household food security in households with more diversified livelihood strategies are greatly reduced in the face of climatic variability and weather-related losses, but diversified livelihood strategies nonetheless build the resiliency of household food security more effectively than strengthening the household socio-demographic profile. However some development agencies still design programs that meet the dual needs of livelihood diversification (which often leads to outward migration from villages) and strengthening demographic household factors (de Sherbinin et al. 2008).

No statistically significant difference existed in overall livelihood strategies between the two communities. In almost two-thirds of households, a household member earned wages outside the village (whether agricultural or otherwise) but about 70% of households still counted natural resource-based activities (agriculture, fishing, hunting and forestry) as the main household income earning activity. Analy-

Table 12.6 Food security and climatic variability, ordinary least squares regression

Model 5A	
Constant	1.42 (7.90)***
Location	0.57 (2.33)
Health security index	0.01 (0.04)
Water security index	−0.42 (0.89)*
Flood or droughts	−0.24 (−1.58)*
Households with physical assets loss	−0.38 (−1.02)
Households with injury or death	−0.34 (−1.76)*
Deviation in max. daily temp.	0.25 (0.69)
Deviation in min. daily temp.	0.32 (1.04)
Deviation in avg. precipitation	−1.04 (−1.44)*
N	134
F value	4.96***
R^2	0.32
Adj.-R^2	0.27

t values in parentheses
[a,b,c]Control variables
****p* / 0.001; ***p* / 0.01; **p* / 0.05

sis of livelihood strategies indicators suggests that the largest statistically significant influence on household food security was when no household member earned an income from outside the community.

Our findings did not suggest any significant role played by the social networking capacity of households in strengthening food security. Household interviews in both communities suggested that the action of households seeking assistance, and that of local government officials providing assistance, depended mostly if not exclusively on political affinities and relationships among the actors, while as elsewhere, the longevity and continuance of such networks were probably invaluable (e.g. Murphy 2007; Adger et al. 2005; see Fig. 12.1). In order to focus on the relationship between food security, climatic change and adaptive household capacity, we controlled for potential differences in situational factors (or 'sensitivity factors' in the IPCC model). Household location, whether in Nariva or Caroni, was not a significant influence on food security in the main models, and only the Water Security Index had a statistically significant influence on household food security.

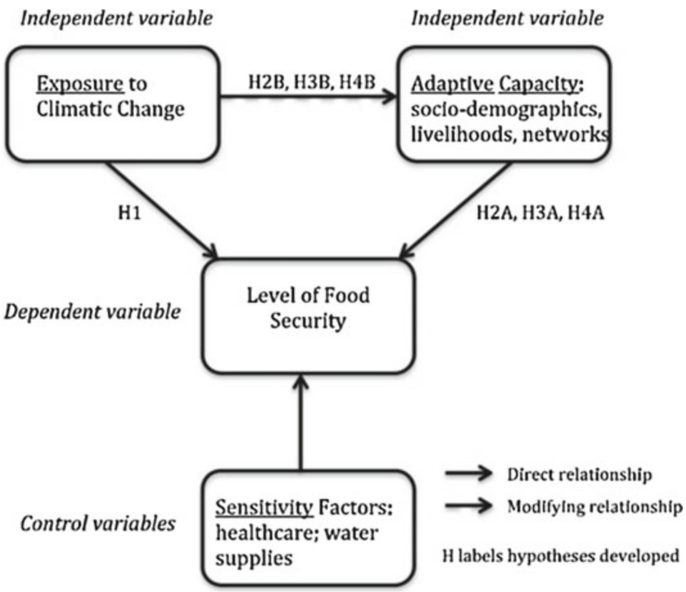

Fig. 12.1 Theoretical framework for food security in the face of climatic change in 'at-risk' households

12.4 Conclusions

The food security of rural, wetland households in Trinidad and Tobago is already at risk and will be severely eroded under climate change. Climate variability and weather-related disasters may reduce the positive effect of adaptive capacity factors on food security, hence increasing food security must rely on a multi-pronged approach to enhancing household adaptive capacity to offset losses expected from climatic change. Improvements in access and infrastructure cannot alone increase or regenerate household adaptive capacity, but can play a role in relieving some of the impacts of climate change on households.

The most beneficial interventions to strengthen the socio-demographic profile of households and ultimately increase food security would be to raise the level of formal education of household heads and assist households with the time- and resource-consuming activities of dependent care. The former would require greater emphasis on rural education extension, adult learning, local skills development education and training initiatives. The latter could be considered through government or public–private partnership initiatives to provide community children daycare and elderly care, relieving the burdens of productive household members. All that depends on sensitive and well-funded public policy. The most beneficial intervention to diversify livelihood strategies and increase food security would be to create mechanisms that provide opportunities for at least one household member to earn an income outside of the village, and, even more preferably, outside of a natural resource-dependent activity.

Loss of physical assets from flooding and injuries or deaths causes the most significant decreases in food security. Local flooding disaster management and relief plans need to be developed in conjunction with local communities. Post-impact assistance also must be developed to ensure, for instance, that households with physical asset losses (e.g. shelter, livestock, crops, equipment) are quickly compensated through workable mechanisms (e.g. direct or indirect payments). These interventions necessitate more effective intra-agency coordination among government bodies, and between government and local communities. The lack of access to health and water infrastructure indirectly debilitates household food security; long travel times to distant health centres consume household time that could be spent in wage earning activities, and lack of regular potable water supplies leaves household members at risk of illness. These findings and recommendations have applicability in other rural, resource-dependent communities that are not necessarily wetland ecosystems, and in other rural communities across Caribbean SIDS. Future studies on should consider two other points. First, land tenure influences food security, but obtaining this information through interviews does not ensure accuracy. Second, the complexities and nuances of local politics and the history of politics impinge on sustainable development of these communities and influence household adaptive capacity. Indeed, sadly, while this study has provided extensive empirical data, evidence and analysis of food security and household adaptive capacity, several interviewees pointed out to us that numerous researchers had asked similar questions over the years, but 'their condition remains the same'. Meanwhile the climate is changing.

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Chapter 13
The Role of Social Capital in Influencing Knowledge Flows and Innovation in St. Lucia

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Abstract This analysis traces how different forms of social capital embedded within community-based social networks may affect smallholder farming system innovation in support of food security in the Caribbean. In two rural communities in Saint Lucia, the strong presence of interpersonal agricultural knowledge networks operates to facilitate farmer-to-farmer knowledge exchange, increase farmer access to information and connect farmers to sources of support. In both communities, 'peer farmers' were reported as being the primary source of new agricultural knowledge for farmers, with government 'extension officers' the secondary source. Comparative social network analysis reveals how different forms of social capital within the two agricultural knowledge networks can affect self-reported farmer innovation in different contexts. We then identify a number of opportunities for policy initiatives to better support, coordinate and enhance innovation opportunities among smallholder farmers in the Caribbean to increase their adaptive capacity in the face of environmental change. The findings provide evidence and insights on how social networks and social capital can support agricultural development and food security in the Caribbean.

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13.1 Introduction

Despite extensive research and technological investments in international agriculture, how institutional arrangements support or undermine sustainable farming systems generally remains poorly understood (von Braun 2009; Godfray et al. 2010; Grote 2014; Saint Ville et al. 2017a). Importantly, agricultural system innovation in high risk or fragile natural environments requires careful institutional management of informal and formal knowledge systems (Brooks and Loevinsohn 2011), particularly in the context of the smallholder farmers operating in developing areas (Foley et al. 2011; Anthony and Ferroni 2012; Saint Ville et al. 2017a). Many studies have identified the potential for smallholder agro-ecological approaches to promote social and ecological sustainability in different developing area settings (Pinstrup-Andersen and Hazell 1985; Conway 1987; Pinstrup-Andersen and Herforth 2008). However their potential to innovate is often undermined by limited access to resources, low levels of technology adoption, difficulties in coordination, asymmetries in information flow, and high levels of exposure to external and internal shocks (Kydd and Dorward 2004; Birner and Resnick 2010). The smallholder farming systems in Caribbean SIDS confront additional difficulties to innovation (Lowitt et al. 2015b; Saint Ville et al. 2015) including high levels of exposure to market shocks, competition from relatively cheaper imports, resource conflicts from growing tourism development and losses from extreme weather events and other natural disasters (Timms 2006, 2008; McGregor et al. 2009; López-Marrero and Wisner 2012).

Innovation adoption studies began with the Green Revolution's quest to better understand the transfer to farmers of divisible agricultural technologies developed at research institutes and universities (Zilberman et al. 2012). Agricultural innovation theory and practice then generally equated food security with food availability (Maxwell and Wiebe 1999; Scoones et al. 2009). More recent developments have accepted food security as multidimensional, comprising food availability, accessibility, utilization and stability (Pinstrup-Andersen 2009). Despite this generally accepted multidimensionality, the concept of food security has challenged Caribbean governments partly because of the initial bias towards relying on technological and market-driven solutions to increase food production (Sheeran 2010; Saint Ville et al. 2017b). Smallholder farmers in the region have often faced market-led (Isaac et al. 2012), or supply-led innovation pressures termed 'technology push' (Pant 2013: 341), which have generally not led to enduring solutions (Saint Ville et al. 2017a). Consequently, agricultural innovation efforts to enhance Caribbean regional food security are being increasingly recognized as complex and context-specific (Weis 2004; FAO 2012; Isaac et al. 2012; Lowitt et al. 2016). Recent research has identified access to markets, financing and knowledge networks as critical constraints facing smallholder innovation in the region (Lowitt et al. 2015b). In other contexts, researchers highlight the need to better understand how innovation is shaped by relations between social actors (Leeuwis and Aarts 2011), and the flow and sources of knowledge that support agricultural innovation (Pretty et al. 2011). However, little, if any, empirical research has explored the relationships between actors in contemporary Caribbean agricultural systems and how these interactions may work to enhance or limit smallholder farmer innovation in support of food security challenges.

Social capital, defined as the enduring connections of networks, reciprocity and social norms that exist among a group of social actors (Ostrom 2000), provides a particularly useful conceptual framework when seeking to understand how interactions between actors in smallholder farming contexts can affect innovation (Lowitt et al. 2015b). In particular, it has been shown to play an important role in developing area contexts where strong social ties function to counter poorly developed or weak institutions (Fafchamps 2006; van Rijn et al. 2012; Lowitt et al. 2015a). For example, social capital has been used to assess the barriers and opportunities for rural community collective action (Rastogi et al. 2014; Rahman et al. 2015); to improve understanding of agricultural innovation in smallholder farming systems (van Rijn et al. 2012); to help design more integrative and decentralized policy frameworks (Bodin and Crona 2009; Crona and Hubacek 2010); and to enhance collaborative governance through supportive community institutions (Compton and Beeton 2012). Through such research, social capital has been usefully conceptualized as comprising three dimensions: *bonding* social capital, which includes the horizontal connections found within a group, (also referred to as 'strong ties'); *bridging* social capital, involving the horizontal links that are found connecting or bridging individuals who belong to distinct groups ('weak ties'); and *linking* social capital, described as vertical ties to sources of power and finance developed among social actors involved in shared tasks to improve the common good (Sabatini 2009). While many studies have identified the positive contributions of different forms of social capital to communities, others have identified the 'dark side' of social capital (Rubio 1997; Ballet et al. 2007). For instance, 'network closure' (Granovetter 1973;) can result from bonding social capital leading to increased homogeneity of beliefs, behaviour, and knowledge within the network while reducing exchange with outsiders (e.g. Barnes-Mauthe et al. 2015). Social capital can also favour those who are already well-resourced (Fafchamps 2006; Maertens and Barrett 2013), and may lead to associations that undermine the greater societal good (van Deth 2010).

Recognizing that previous research has identified positive and negative relationships between social capital, information flow, and agricultural innovation in smallholder farming systems (van Rijn et al. 2012; Dessie et al. 2013; Speranza 2013; Wossen et al. 2013; Chen et al. 2014), relatively little is known about the nature and extent of social capital in Caribbean agriculture (cf. Saint Ville et al. 2017a), despite an improved understanding of social capital dynamics within Caribbean smallholder farming systems having been identified as having the potential to inform sustainable natural resource management policy and practice (Adger 2003; Pelling and High 2005) and contribute to regional food and nutrition security objectives (Lowitt et al. 2015a). In this chapter, we present the results of a comparative case study designed to explore how the different forms of social capital embedded within community-based social networks may affecting smallholder farmer innovation in Saint Lucia with a view to informing future research and policy in the region.

13.2 Saint Lucia

Saint Lucia is a volcanic island with rugged topography in the Caribbean archipelago. The land area is 616 km^2, with just 9% of this considered arable (Cox et al. 2005). Smallholder farms, typically less than two hectares in size, dominate the domestic agriculture-food system which is generally small-scale and rain-fed (Government of Saint Lucia 2007). Seasonality in rainfall, with heavy cyclonic rains in the wet season (from May to November) and a pronounced dry season from December to April, combined with considerable spatial variation in annual rainfall from mountainous to coastal regions (Isaac and Bourque 2001; Cox et al. 2005) challenge efforts at consistent food production. The historical dominance of plantation sugar estates on the flatter areas has resulted in approximately 87% of smallholder farms practicing cropping on hillsides with generally fragile soils (Rojas et al. 1988), contributing to high rates of soil erosion and land degradation in many agricultural watersheds.

Through a collaborative initiative between McGill University and the University of the West Indies (2011–2014) two rural farming communities were selected in order to analyze the various factors affecting innovation among smallholder farmers: Black Bay and Marquis (see Fig. 13.1). These two communities have quite different local histories and institutions supporting smallholder agriculture (see Table 13.1), that provided an excellent opportunity to conduct a comparative analysis of the role of social capital.

The agricultural history of both Black Bay and Marquis began with sugar plantations but subsequently followed divergent paths. In the case of Black Bay and

Table 13.1 Summary of community characteristics in Black Bay and Marquis

Community characteristics	Black Bay	Marquis
Active agricultural cooperative involved in domestic production	Yes	No
Rural community	Yes	Yes
Land ownership	Leased (owned by the government)	Owned/family land/leased (private ownership)
Land capability	Alluvial, fertile, flat	Alluvial, fertile, flat and steeply sloping
Banana production history	No	Yes
Livelihood strategies	Fruits and vegetable for the domestic market	Fruits and vegetable for the domestic market
[a]Number of households in community (estimated involvement of households in agriculture)	138 (50%)	212 (50%)

[a]Based on Enumeration Districts, Saint Lucia 2010 Population and Housing Census: Preliminary Report, 2011

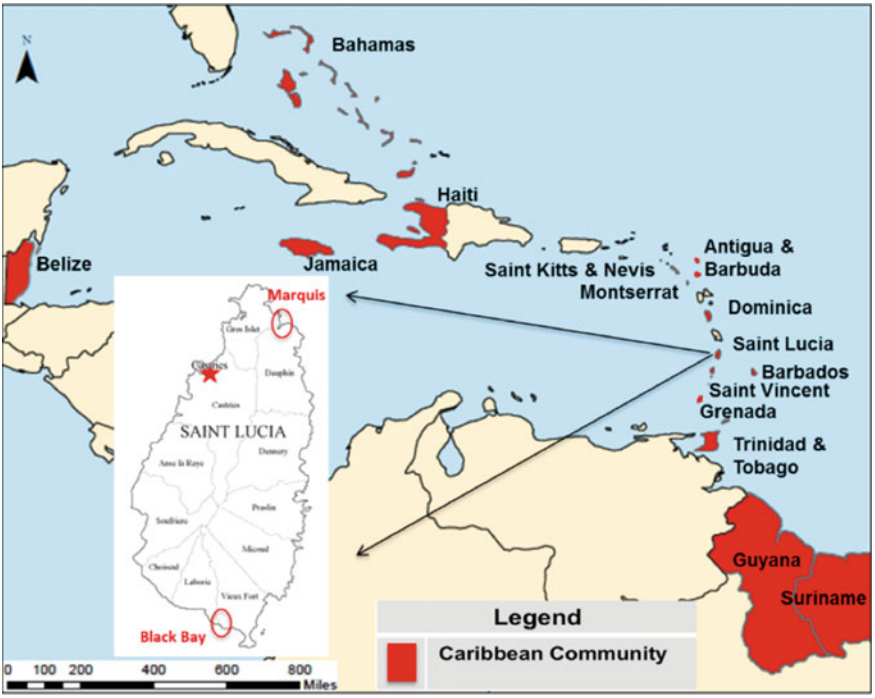

Fig. 13.1 Map showing Saint Lucia in the Caribbean Archipelago and all fifteen member states of the Caribbean Community (CARICOM). An inset map of Saint Lucia shows the position of the two study sites relative to the capital city, Castries. *Data source (inset map):* http://www.d-maps.com/pays.php?num_pay=157&lang=en

surroundings, after slaves were freed from plantation labour in 1838, the sugar estate was restructured into one of four central factories (Harmsen et al. 2012). Amalgamation made the Vieux Fort Factory the major landowner (4,000 acres/1,619 ha of land) and employer in the area until 1936, when the Vieux Fort Sugar Company shut down causing economic hardship (Harmsen et al. 2012). In 1974, the British Development Division initiated the Black Bay Vegetable Project to promote economic development, consisting of eleven family farms each leasing ten hectares of alluvial plain (IICA 1989). Due to administrative inefficiencies, production fluctuated and stalled from 1974 to 1978, when another external injection of technical, financial and administrative resources re-catalyzed agricultural production. However, these increases were short-lived due to natural disasters and recurring administrative mismanagement (IICA 1989). By 1988 the project's membership had increased (to the current size of 35) and the production acreage doubled (IICA 1989). In 2008, the Black Bay Cooperative became formally incorporated, responsible for managing the state-owned land by allocating farm units (typically 1–2 acres) to its members. While each member independently operates their farm, they engage in voluntary shared product marketing through the cooperative. This involves the cooperative sourcing produce from members in response to orders received (primarily from hotels). Product grading, weighing and packaging takes place at the cooperative and is then delivered to the buyer. This is the primary revenue generating activity of the cooperative, with monthly deductions from the payments to members used to support transport, facilities, utilities and staff.

Unlike Black Bay, where agricultural lands were owned centrally by the state and ultimately managed through the cooperative, farmers in Marquis enjoyed access to mountainous forested lands on the periphery of Marquis Estate lands. After the abolition of slavery in 1833, Marquis' 1,032-hectare sugar estate remained but experienced labour shortages as ex-slaves opted to hunt, subsist and squat in nearby mountains rather than enter into voluntary employment on estates. Planters responded by using their legislative authority to institute vagrancy laws, high land sales taxes and licensing fees on transportation to restrict land ownership and create forced labour conditions. Despite these restrictive strategies, where lands were available, a land-owning peasant class developed and by 1890 they produced one-fifth of all sugar grown in St. Lucia (Harmsen et al. 2012). By 1897, an estimated 6,000 ex-slaves purchased small farms across the island representing a 347% increase in land ownership levels from 1845 (Adrien 1996). Declines in sugar markets in the early 1900s resulted in severe economic hardship but in 1953, things improved when the British government created a guaranteed market and awarded a British company the contract to buy all Windward Island bananas. This transition from sugar to bananas created many economic opportunities and by 1965, bananas represented 90% of Saint Lucia's total exports, grown by 12,479 registered growers (Grossman 1998; O'Loughlin 1968). Booming export market conditions and labour shortages in Marquis resulted in the private sale of half of the estate (405 ha) in 1980. Initially targeted towards ex-workers at reduced cost, with farm sizes ranging from 1 to 10 ha, many failed to meet financing requirements and the majority of the land was sold to people living outside the immediate local community. Post-liberalization, with the loss of the protected market in Europe (1999), farmers in Marquis increasingly abandoned banana production and joined Black Bay farmers in producing fresh fruits and vegetables for local markets. These private farmers produce, harvest and market their fresh foods for the domestic market independently. On a weekly basis, their short-term crops (including cucumber, peppers, lettuce, green onion, eggplant, okra, tomatoes) are sold to supermarkets, the government-controlled marketing board and directly to consumers at the Castries Farmers Market. Friday and Saturdays are the major selling days at the market, with crop availability, quality and volumes highly variable.

Although Black Bay and Marquis have different historical paths and social-ecological conditions, the majority of the smallholder farmers in both communities grow fresh fruits and vegetable for the domestic market. Black Bay farmers have a longer history and more experience producing for the domestic market than farmers in Marquis. Farmers in both communities have easy access to irrigation water from nearby rivers. Other common characteristics include low precipitation due to their proximity to the coast; and location on flood plains with fertile, alluvial soils. The main agricultural commodities included fruits, roots, and vegetables. Key differences occur in land tenure arrangements and the operation of an agricultural cooperative. In

Marquis, farmland is privately owned and held across generations as 'family lands' while in Black Bay all farmland is publicly owned and leased to individual smallholder farmers, the majority of whom access this land through their membership in the Black Bay Cooperative.

13.3 Methods

Following a combined grounded theory–case study research design, we used a mixed methods approach to data collection and analysis. We sought to explore the association between smallholder farmer social capital and self-reported innovation at the household level (using egocentric analysis) and community level (using sociocentric analysis), where such multilevel analysis increases the comprehensiveness of social network research by identifying the processes occurring at different levels. During 2012, we conducted 112 farmer household surveys (40 in Black Bay and 72 in Marquis) following a purposive snowball sampling strategy and collected qualitative data through eight farmer focus groups and 55 key informant interviews with community leaders. We also directly observed community farmers during various stages of marketing and production, and used the Socio-Spatial Knowledge Network (SSKN) method (Gregory and Urry 1985), which has been widely applied in the health sector, identify community spaces for effective knowledge dissemination. This involved community scoping and discussion with community leaders, including teachers, elected officials, community-based organizations, faith-based organizations, health care workers and civil servants, to better understand the different community issues, and understand local needs and concerns.

Smallholder farmer households were the primary unit of analysis and included those directly involved in farm production, such as agricultural labourers, subsistence producers and commercial scale farmers. Qualitative data were important to our study due to the complexity of the issues being explored and the need to contextualize the survey data, including understanding various motives, constraints and mechanisms in more detail. Focus group discussions were used to collectively clarify views, attitudes and motivations and delve into shared understanding. Of the four focus groups conducted in each community, at least one brought together young farmers, and another focused on the distinctive perspectives of women farmers.

The study adopted a broad definition of innovation, as being an 'idea, practice, or object' perceived as novel by a social actor or adopter (Rogers 1983: xviii). We operationalized this definition in our study as adopting a new crop, new way of doing things, new planting method, new pest management, soil or water management technique or some other technological learning in agriculture in the past five years. We used two questions to assess self-reported innovation of respondents: (1) Have you ever been involved (at any time) in an agricultural project with the Ministry of Agriculture? (past innovation variable); and (2) In the last 5 years have you developed or adopted a new crop, a new way of doing things, new planting method, new pest management technique, soil or water management or some technological learning in agriculture (recent innovation variable)? Since the practical aim of the study was to assess how social capital might influence knowledge networks and self-reported innovation in Caribbean smallholder agriculture, the level and nature of the particular innovation was self-reported and not independently verified.

Networks compose interactions at multiple levels that may be viewed from the individual, dyad, subgroup and entire network level. We conducted our social network analysis at two levels, the egocentric and sociocentric level. At the egocentric level of analysis, we viewed the network from the perspective of a focal node (ego), based on relations of 'knowledge received', and 'knowledge shared'. We looked at direct connections between the ego and other nodes (alters) (farming households in the community) and the connections between these, in terms of 'Size' (the number of direct connections between the ego and other actors) and 'Ties' (the total number of ties between the alters in the ego network). We statistically tested the level and significance of association between a respondent's self-reported innovation and their 'sizes' and 'ties'. For the sociocentric network analysis, we also examined the larger knowledge network to see overall patterns in the network structures of the two farming communities. Multiple connections (multiplex relations) were mapped to identify the level of overlap between the ties. These multiplex relations were used to develop the community knowledge networks by overlaying three types of ties between respondents and the other farmers in the community (knowledge received, knowledge shared, and kinship/blood ties). The resulting maps of these overlays of relations allowed us to better capture the nature of the bridging (non-overlap with kinship ties) or bonding (overlap with kinship ties) social capital. A more detailed analysis of the methodology is given elsewhere (Saint Ville et al. 2015; see also Saint Ville et al. 2017a, b)

13.4 Networks and Social Capital

A summary of the respondent profile in each community, indicating that most were male and had no marital partner (Table 13.2). Most respondents had lived and farmed in either Black Bay (75%) or Marquis (61%) for 11 years or more, and more than half had been involved in farming for 21 years or more. The median age range was 45–54 (33%) in Black Bay and 55–64 (31%) in Marquis. In Marquis, 18% of respondents owned their farms, 40% farmed on family lands and 15% leased from private landowners. 'Family land' is a generational land title and exists in St. Lucia as part of French colonial inheritance laws and results in lands being owned across generations of a family. Typically the land is accessed and used by a multiplicity of heirs and successors without title by virtue of shared bloodline. By contrast, 87.5% of respondents from Black Bay farmed on government land. Over half of respondents reported farming as providing between 75 and 100% of their income, with similar proportions reporting that their farms were producing under-capacity. Respondents were primarily dependent on weekly farmers' markets as the primary endpoint for the sale of their crops. Approximately 12% of respondents were involved in banana

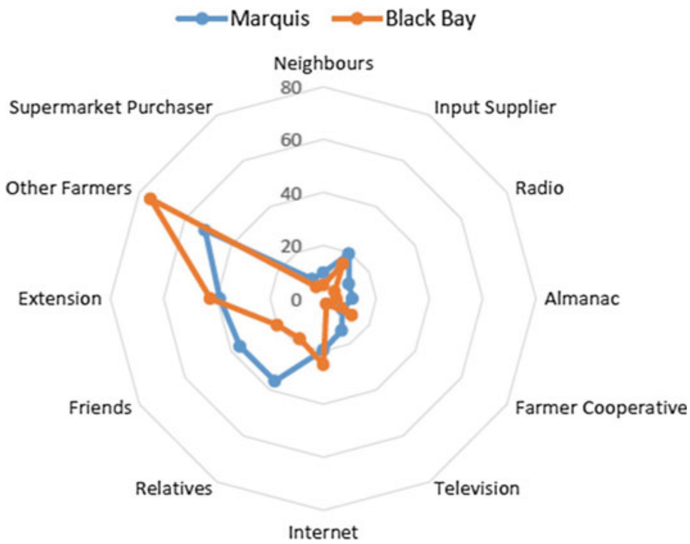

Fig. 13.2 Percentage of respondents who reported receiving new agricultural knowledge from different knowledge sources showing the important role played by 'peer farmers' relative to extension officers in both communities

production with the majority of these respondents (17%) being from Marquis. More than 50% of respondents had never been involved in banana production while 38% of respondents who had been involved in export banana production exited this market in the 1990–1999 period. General trust was low among respondents (85% in Black Bay and 70% in Marquis), and community trust also low (68% in Black Bay and 64% in Marquis). In Marquis, 42% of respondents claimed membership in the Babonneau Fair Trade Association (a banana exporter group) or other farming groups, while in Black Bay, 65% of respondents held membership in the Black Bay Cooperative.

In both communities (75% in Black Bay and 51% in Marquis) 'peer farmers' were reported as being the primary source of new agricultural knowledge for farmers, with government 'extension officers' the secondary source (39% in Black Bay and 43% in Marquis) (Fig. 13.2). Innovations identified by respondents included: new crops (kale, zucchini), new planting methods, new pesticides, non-chemical weed management such as plastic mulch, chemicals such as hormones to induce flowering, soil stimulants, use of heavy equipment, new irrigation techniques and seedling development. A key difference in the two communities was the role of 'relatives' and 'friends' in providing new knowledge, reported in Marquis at 36% and 36% compared to Black Bay at 18% and 20% respectively.

Marquis and Black Bay respondents showed similar trends in their self-reported innovation activities. In both communities, respondents had a positive association with innovation resulting from their participation in past agricultural development projects. Descriptive statistics supported this assertion with 72% of respondents expressing a willingness to participate in future projects. Two-thirds of respondents

Table 13.2 Demographic and farm characteristics of survey respondents

Respondent attributes	Black Bay (n = 40)	Marquis (n = 72)
Demographics		
Male	93%	72%
Without a partner	40%	39%
Lived in community for more than 11 years	75%	61%
Median age range	45–54 (33%)	55–64 (31%)
Completed primary school	33%	35%
Completed secondary school	43%	40%
Completed college	18%	13%
Completed university	5%	10%
Land ownership		
Land owner	13%	18%
'Family land' owner	–	40%
Leased-Government	87.5%	–
Leased-private	–	15%
Co-owner	–	8%
Share tenant	–	11%
Production/Marketing/Membership		
Less than ¾ of farmland under cultivation	59%	56%
More than ¾ of farmland under cultivation	41%	44%
Farming contributes more than 75–100% of household income	58%	50%
Weekly farmers market–main market	32%	69%
Past involvement in banana production	30%	43%
Current involvement in banana production	2.5%	17%
Membership in cooperative/farmer group	65%	42%
Trust		
General trust-most people cannot be trusted	85%	70%
Community trust-'strongly agreed' and 'somewhat agreed' that "you have to be alert or someone in this community is likely to take advantage of you"	46%	64%

in both communities reported that they had adopted an innovation in the past five years while 37% had been involved in past agricultural projects (donor-funded or with the Ministry of Agriculture). In focus group discussions, farmers raised a wide range of issues with implications for their level of interest in particular innovations. Most important were challenges related to finding markets to sell perishable produce, growing incidences of pest infestation, theft, and difficulties accessing labour. There was wide consensus that a lack of domestic markets was the primary challenge limiting their ability to produce and innovate. More specifically, participants identified inconsistent supply of inputs and highly variable prices as challenges arising from the small domestic market, the large number of producers, lack of contracts (based on the small size of producers) and limited coordination among farmers. At certain times of the year, such as the dry season from January to May (called '*kawenm*' by farmers in *Kweyol* Creole), optimal conditions exist for growing crops such as tomatoes, cucumbers and watermelon, resulting in overproduction and drastically lower prices. While participants acknowledged that this situation proved detrimental to all farmers, there appeared to be an inability or unwillingness to formally organize and coordinate production, suggesting that greater communication among farmers will be required in order to foster a level of collective action in the form of voluntary coordination of production planning. When asked why the efforts of the Ministry of Agriculture to develop formal production scheduling plans to reduce risk and curtail overproduction, farmers voiced concerns relating to low trust, and indicated their dissatisfaction with the associated risks to their livelihoods (without any means to ensure compliance by Ministry officials). As explained by one Black Bay farmer in reference to the short-lived production scheduling plan initiated in the late 1990s: *'they're asking you to take risk that they are not taking themselves'*. These risks were generally viewed as resulting from the ease with which the entire production plan could be undermined by noncompliance by any party. In the absence of formal contracts and production planning, the clear preference of the farmers we interviewed was for them to continue their production scheduling informally by observing the crops and volumes being planted by the other farmers in the area.

13.4.1 Egocentric Network Analysis

The frequency distribution of 'size' and 'ties' in the social networks of farmers surveyed in Black Bay and Marquis, reveals key differences in the number of links between farmers that supported interpersonal knowledge networks (Fig. 13.3). The Marquis smallholder farming households comprised almost double the 'size' and 'ties' of the Black Bay households. The correlation between measures of social capital (direct links with other farmers in their community—'size' and indirect links among alters—'ties') and self-reported innovation (Table 13.3) shows a stronger positive relationship between respondents who self-reported as 'past innovators' and 'size' 0.406 (0.000) and 'ties' 0.491 (0.000), and those who self-reported as 'recent innovators' and 'size' 0.397 (0.000) and 'ties' 0.404 (0.000), suggesting that the

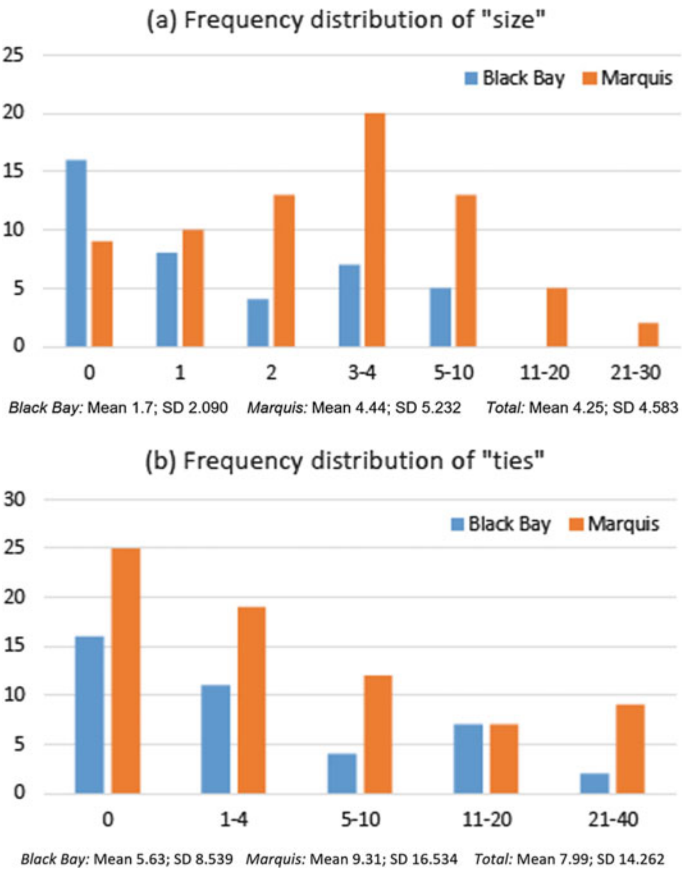

Fig. 13.3 Frequency distributions of **a** 'size' and **b** 'ties' for Black Bay and Marquis. Mean 'size' and 'ties' in Marquis were almost double that of Black Bay

Table 13.3 Correlation between ego network metrics (size and ties) with innovation adoption

Independent variables	Recent innovation	Past innovation	Innovation (combined "recent" and "past")
"Size"	0.406(0.000)	0.397(0.000)	0.471(0.000)
"Ties"	0.491(0.000)	0.404(0.000)	0.481(0.000)

larger the farmer's network of indirect connections (friends of friends), the greater the likelihood of them innovating.

13.4.2 Sociocentric Analysis of Interpersonal Agricultural Knowledge Networks

The number of respondents (nodes) per community (k) were 40 in Black Bay and 72 in Marquis (Table 13.4). The average number of connections between actors in the network (shown graphically as the number of lines connected to each node) was 4.45 in Black Bay and 6.58 in Marquis. Out of these total possible ties, respondents in Black Bay reported only 62 ‘knowledge received’ ties, and 59 ‘knowledge shared’ ties; corresponding values for Marquis were 106 and 102 ties. In Marquis, ‘kinship ties’ comprised the largest network component (268), unlike Black Bay where knowledge ties were largest. Network density (the proportion of all possible ties against those that are actually present) was 11.4% in Black Bay and 9.3% in Marquis, indicating that information diffuses relatively slowly among nodes in both networks, but this may mask community variations associated with the quality of interpersonal ties. The distance measure considers how the actors are embedded in the network by looking at the number of links that separate them. For example, two adjacent actors have a distance equal to one. This means that in one step, information can go from one farmer to the other. In contrast, if A tells B, and B tells C (and A does not tell C), then farmers A and C are at a distance of two. Where distances are great, it may take a long time for information to diffuse across a population. In our case studies, average distance measures were 2.610 in Black Bay and 2.365 in Marquis, again suggesting that there are more than two people on average separating information diffusion from one farmer to another in the network.

The social structure of the smallholder farmer knowledge networks of our respondents from the Black Bay (4a) and Marquis (4b) communities was graphically depicted (Fig. 13.4), with the nodes representing respondents and the lines the relation between two nodes. To help clarify the ‘strong ties’ in each network, line colours were used to show the overlap of relations. By mapping the structures created by

Table 13.4 Network summary data for Black Bay and Marquis

Network characteristics	Black Bay (40 nodes)	Marquis (72 nodes)
Types of ties found between respondents	No of ties	No of ties
New farming knowledge shared	59	102
New farming knowledge received	62	107
Kinship	53	268
Support requests	33	68
Potential support	50	102
Friendship	45	64
Average degree	4.450	6.583
Density	0.114	0.093
Average distance	2.610	2.365

these different kinds of relationships (kinship, knowledge), we identified different dimensions of social capital operating in the two communities. The knowledge network of our Black Bay respondents (Fig. 13.4a) consisted of more bridging social capital measured at 31% of overlap between knowledge and kinship. These 'weak ties' connect different groups of people who do not share family bonds. In contrast, the knowledge network of the Marquis respondents (Fig. 13.4b) consisted of higher bonding social capital, or 'strong ties' measured by 61% of overlap between knowledge and links to family members. The intersection of knowledge and kinship relations in the Marquis data results in a more centralized network dominated by a few central nodes connected by family ties.

13.5 Discussion

Over half of our survey respondents reported farming as being their only source of income. This makes them vulnerable to shocks resulting from either internal or external factors. In the case of Saint Lucia, smallholder agricultural livelihoods are often based on highly vulnerable production systems creating 'poverty traps', generally characterized by a lack of connectedness and low resilience. This creates a significant challenge for smallholder agricultural policy in Saint Lucia and points to the need to foster greater trust and interaction between social actors (farmers) and institutions in the agriculture-food system. More specifically, there is a need to assist smallholders to better connect across the system in order to foster their capacity to adapt in the face of change and work collectively to address common problems (Carpenter and Brock 2008). Issues that undermine such adaptive capacity include limited formal education, small farm sizes (<2 acres or 0.8 ha), producing undercapacity, low trust, and informal marketing arrangements, resulting in a relatively high degree of household vulnerability to shocks. The following quotes provide some insight to the situation facing smallholders in our study area:

> … anything that I can plant, I plant…once I can make a dollar, so long it comes to my mind, I plant,… whether I make something out of it or I make nothing out of it, I am just trying something (female farmer Marquis);

> Well sometimes even though you know that there is a glut, there are not many things that you can plant and there are so many farmers. And you yourself you have to live, you have children you have your family to feed. So sometimes, you just have to plant it you know (male farmer Black Bay).

Social relationships have been identified as performing a critical function in building (and limiting) adaptive capacity in smallholder farming systems (Pretty 2003). According to Norris and Stevens (2007), if farmers have resilient social supports, then it is likely that they would be used in times of uncertainty or resource limitations. Pretty et al. (2011) further suggested that sustainable agricultural intensification in low-yield areas (of Africa) depend upon developing new forms of social infrastruc-

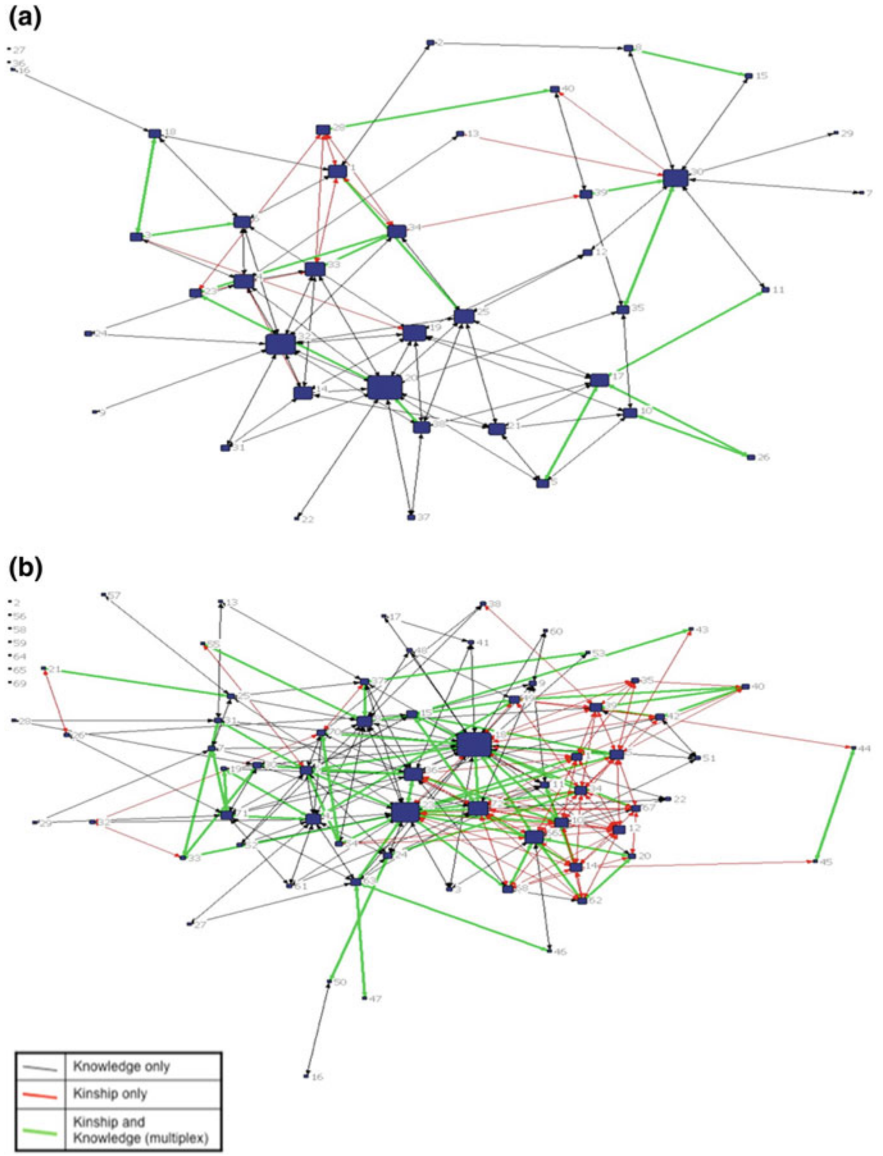

Fig. 13.4 Depiction of multiplex relations and overlap of knowledge shared, received and kinship ties in the knowledge networks of **a** Black Bay-40 nodes; **b** Marquis-70 nodes. Node sizes were adjusted by degree centrality to highlight the key nodes in the network

ture among smallholder farmers, involving the leveraging of their social capital in support of adaptive capacity in resource-scarce settings (Pretty and Ward 2001).

Our sociocentric analysis generally supported these observations, indicating that the presence of interpersonal agricultural knowledge networks supported the production capacity of smallholder farmers in both communities. The characteristics of these networks were quite different, reflecting the particular social-ecological characteristics of the community and supporting the need for context-specific approaches to agricultural extension and innovation (Hellin 2012; Wood et al. 2014). For example, the farmer knowledge network in Black Bay (Fig. 13.4a) appeared to be based largely on bridging social capital with kinship playing a relatively minor role. Such bridging social capital is known to provide sources of new information (Granovetter 1973) and can facilitate the diffusion of innovation (Sabatini 2009; Scott 2011). In Marquis, the knowledge network (Fig. 13.4b) was based more directly on bonding social capital, known to foster group identity and cohesiveness, but be less responsive to externally driven innovation and change processes (Burt 1995; van Rijn et al. 2012). Despite their differences, both knowledge networks performed a critical function in the smallholder agricultural innovation system, by providing a trusted means to support innovation, and facilitate farmer knowledge exchange beyond what was available through the formal institutions of government.

Not only did our findings reveal that respondents employed social networks to better connect with each other, but that new knowledge sourced from interpersonal networks were generally considered of greater importance than those provided by the state-run agricultural extension services. Our results also indicate that there may be declining importance placed on state-led agricultural extension services compared to ‘peer farmers’, which is another area that would benefit from targeted research in the Caribbean context. Numerous factors might explain the limited effectiveness of formal extension services in the Caribbean, including weak linkages between agricultural research and education; limited coordination of limited resources; and inadequate adaptation of institutional structures to meet existing needs and resource limitations. Recent research in Jamaica has highlighted the importance of shared local knowledge among smallholder farmers to their adaptive capacity (Campbell and Beckford 2009; Gamble et al. 2010). By experimenting with different approaches to agricultural extension services to foster peer-to-peer interactions and reciprocal knowledge flows between farmers, the interpersonal and procedural trust required for collective action may be enhanced (Hellin 2012; Schroeder et al. 2013; Yang et al. 2014).

Despite differences in the dimensions of social capital that comprised the knowledge network in the two communities, the self-reported level of innovation among respondents in each community showed no significant difference. Egocentric analysis, designed to capture the social networks of our sample of individual smallholders, showed that although the direct links to other farmers in the network were significant in farmer self-reported innovation, the combined effect of the direct and indirect links was more significant. This suggested that not only is bridging social capital within the knowledge network potentially positive for innovation, but the links between alters or “friends of friends” in the network is also important. That conclusion is supported by van Rijn et al. (2012) who suggested that the larger the network of adopters (direct and indirect links), the greater the likelihood that farmers would adopt innovations due to increased knowledge, access to resource and sources of support (see also Wossen et al. 2013).

The lack of significance in self-reported innovation between respondents in the two communities despite wide variabilities in their egocentric social networks and the differences in the provisioning knowledge networks provides an interesting result in itself. One possible explanation for this is that farmers are able to receive support that influences their self-reported adoption of agricultural innovation through different mechanisms and types of interaction in each community. For example, in the case of Black Bay, farmers can share knowledge and work together with fewer but more diverse farmers, to achieve shared outcomes through regular formal and informal gatherings at the cooperative (including annual meetings, committee meetings, weekly trips to the office to deliver harvested crops targeted for hotels, workshops planned by the Ministry of Agriculture to address topical issues in agriculture, and projects being undertaken through the cooperative by donors). In contrast, Marquis farmers accessed new agricultural knowledge through larger numbers of interpersonal ties, mainly of primarily family-based interactions that generally required greater personal investments of time, more deliberate interaction with more people and social expectations of reciprocity. As noted by Granovetter (1973), these “strong ties” are a costly investment because of the amount of time social actors need to spend together in order to foster and sustain an emotional connection, intimacy and commit resources to reciprocity of exchanges. Our conclusions suggest that farmers in Marquis have less time available to participate in other activities. In contrast, farmers of Black Bay, with their knowledge networks based on bridging social capital, function through “weak ties” fostered by the operations of the cooperative and have more time and resources available for innovation. The farmers of Marquis experienced other potential disadvantages since, despite bonding social capital being helpful for the creation of favourable community conditions, ‘network closure’ could develop. Overall while social capital appeared to play a generally equalizing role in fostering innovation in the absence of secure land tenure (Black Bay) and a lack of formal farmer organization (Marquis), more research is needed to look at the differences in capital investment required to achieve this outcome.

While social capital and knowledge networks differed in the two communities, they highlighted some of the pathways available to formal institutions, donors, and NGOs working to enhance knowledge exchange in the resource-poor, smallholder agricultural systems common to the Caribbean. These knowledge networks, built on interpersonal trust, represent resources invested by individual smallholder farmers and their communities to improve communication and knowledge exchange. Because of the limitations in the existing agricultural extension services in Saint Lucia, such interpersonal networks provide a potentially powerful and adaptive mechanism through which to interact with smallholder farmers and ensure better-targeted interventions. Previous research by Osbahr et al. (2010) evaluated four agricultural development projects in southern Africa and revealed the important use of interpersonal networks as platforms from which to build more formal organizations (maize collectives). This suggests that by better linking formal and informal interactions, governments may be able to foster more decentralized and synergistic knowledge production and exchange at minimal additional cost (Mikulcak et al. 2015; Rahman et al. 2015). Better identifying and working with interpersonal networks may also help policy-makers initiate more integrated responses that can link smallholder farmer social capital to the significant human and financial capital of governments, donor agencies, the private sector and NGOs.

13.6 Conclusion

Policy interventions designed to better support smallholder agricultural innovation systems in the Caribbean require creative and decentralized governance approaches to facilitate knowledge flow and build interpersonal and procedural trust. The present study highlights the nature, role and subtle differences in the interpersonal agricultural knowledge networks operating in two farming communities in Saint Lucia. Despite structural differences, farmers in both communities used their social networks to access new agricultural knowledge and innovate, noting that this was a more important knowledge source than state-run agricultural extension services. In Black Bay, the knowledge network was based more on bridging social capital, while in Marquis it was based more on bonding social capital, with implications for how farmers can and do access the knowledge they require to innovate in different contexts. Although the direct links to other farmers in the network were significant for self-reported innovation (past and recent), the indirect links between alters or "friends of friends" were more significant. This indicates that not only is bridging social capital within the agricultural knowledge network necessary to support system innovation, but the combined links between smallholder farmers in the network are essential. By using their social networks to increase their connection to a larger number of farmers, smallholders may improve their adaptive capacity to facilitate knowledge exchange, increase access to resources, and connect to sources of support. Despite the recognized equity challenges associated with social capital, it has a potentially significant role to play in improving smallholder agricultural system innovation in St Lucia and the wider Caribbean, both at the individual and community levels. Our results provide important insight to how these often hidden and decentralized networks may present food security-related policy and programs with an important and adaptive informal mechanism through which to better reach and coordinate smallholders in the absence of other, more reliable, democratic institutions.

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Chapter 14
Eating Meat or Eating Money? Factors Influencing Animal-Source Food Consumption in Timor-Leste

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Abstract Poor dietary quality is an underlying contributor to the high rates of maternal and child undernutrition in Timor-Leste. The majority of households own livestock, however consumption of domestic animal-source food (ASF) is low, while few households report using non-domesticated species. Two hundred and three households with children under 24 months, in 3 villages, were enrolled in a quantitative study of maternal and child dietary diversity, alongside 12 key informants recruited for in-depth interviews and 312 participants, mostly mothers and fathers of young children, for focus group discussions. Participants expressed a desire to consume more ASF. Barriers to ASF consumption included having low-income or limited-income streams, high levels of small livestock morbidity and mortality leading to small or unstable flock or herd sizes, reserving livestock for sale and ceremonies

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and living far from forested areas or where hunting was not allowed. Factors that enabled greater ASF consumption included villages being near forested areas with wild animal populations, observance of a large number of ceremonies of long duration, households with a greater number of small livestock, and where women were able to make autonomous decisions about livestock assets. Policies and programmes designed to achieve sustainable improvements in household nutrition would include a focus on women and improving the health and production of small livestock species frequently utilised by households.

Keywords Animal source food · Undernutrition · Livestock · Timor-Leste

14.1 Introduction

Undernutrition is a major challenge in Timor-Leste, with one-quarter of non-pregnant mothers (aged 14–60 years) being underweight (BMI < 18.5 kg/m^2), and one-eighth having short stature (height < 145 cm) (MoH 2015). Poor maternal nutrition pre- and post-conception leads to increased chances of preterm birth, low birthweight at term (birthweight < 2500 g), neonatal mortality, child wasting (when children are more than two standard deviations below the World Health Organization (WHO) Child Growth Standards median for weight for length/height, WHZ) and stunting, (when children are more than two standard deviations below the WHO median for length/height for age, HAZ) (ACC/SCN 2000; NSD et al. 2010; WHO 2008). In Timor-Leste, a nationally representative nutrition survey in 2013 reported that wasting from acute undernutrition affected 11% of children aged 0–59 months, while stunting from chronic undernutrition affected 50% of children aged 0–59 months (Table 14.1), with 10% of infants already stunted by 5 months (MoH 2015). Child stunting is significantly associated with the thinness of the mother where she was the primary carer (MOH 2015). Although the prevalence of stunting has decreased from 58% since the Demographic and Health Survey (DHS) in 2009–2010 (NSD et al. 2010), it remains unacceptably high given the long-term outcomes including decreased cognitive ability, limited capacity for physical labour, lower earning capacity and increased risk of communicable and non-communicable diseases later in life (DeBoer et al. 2012; WHO 2010a).

Micronutrient deficiencies are also common, with almost 40% of non-pregnant mothers (aged 14–60 years) anaemic (Hb < 120 g/L)—about 40% of which is due to iron deficiency, and 13.5% vitamin A deficient (serum retinol < 1.05 μmol/L) (MoH 2015). In children (aged 6–59 months), 63% are anaemic (haemoglobin < 110 g/L)—of which 30% is due to iron deficiency, 34% are zinc deficient (<8.7 μmol/L) and 8% are vitamin A deficient (serum retinol < 0.7 μmol/L) (MoH 2015). The prevalence of anaemia has almost doubled since 2009–2010, when 38% of children (aged 6–59 months) and 21% of non-pregnant mothers (aged 15–49 years) were reported to be anaemic (NSD et al. 2010). Factors associated with this rise are

Table 14.1 Nutrition status and food consumption statistics for the municipalities of Aileu, Bobonaro and Lautem, and for all of Timor-Leste. Data from the 2013 Timor-Leste Food and Nutrition Survey (MoH 2015) unless indicated

	Aileu	Bobonaro	Lautem	Timor-Leste
Underweight (BMI < 18.5 kg/m^2) (%)				
Non-pregnant mothers (aged 14–60 years)	21.7	36.4	20.5	24.8
Anaemia (Hb < 120 g/L) (%)				
Non-pregnant mothers (aged 14–60 years)	32.3	50.8	38.6	39.5
Stunting (HAZ < –2.0)				
Children 0–59 months	52.3	57.4	39.5	50.2
Wasting (WHZ < –2.0)				
Children 0–59 months	8.3	14.9	5.4	11.0
Anaemia (Hb < 110 g/L) (%)				
Children 6–59 months	53.9	73.6	60.8	63.2
Acceptable household food consumption score (FCS > 42), %	72.7	70.3	65.0	61.3
Adequate dietary diversity (DD ≥ 4) (%)				
Children 6–23 months	42.5	29.5	13.4	27.5
Children 24–59 months	45.6	40.9	23.7	40.6
Consumption of flesh foods (%)				
Children 6–23 months	28.6	26.0	17.6	24.3
Children 24–59 months	27.0	34.3	31.4	31.2
Consumption of eggs (%)				
Children 6–23 months	39.9	24.0	16.9	22.5
Children 24–59 months	30.7	22.2	12.3	24.5
Consumption of meat, seafood, poultry and eggs (%)				
Mothers 15–49 years[a]	37.7	49.8	51.2	52.8

[a]Data from the 2009–2010 Demographic and Health Survey (NDS et al. 2010)

unknown, and other anaemia due to deficiencies in folate, vitamin B2, vitamin B12 and copper, or parasitic, infectious and genetic causes, are yet to be explored.

Inadequate dietary intake is a result of food insecurity and an immediate cause of undernutrition. In 2013, the Timor-Leste Food and Nutrition Survey (MoH 2015) found that 61% of households had an acceptable food consumption score (FCS) (with more than 42 unique foods consumed within the household over the previous seven days), however individual dietary data were not collected for adults. Data collection for this 2013 survey spanned the less-rainy to dry postharvest season when food is more abundant. The 2009–2010 DHS (NSD et al. 2010) collected information on maternal food consumption during the dry and rainy seasons and found that the most common food groups consumed in the previous 24 h were grains (92% of mothers) and vitamin A-rich fruits and vegetables (88%). Fifty-three percent of mothers ate animal-source foods (ASF). No analyses were published of associations between maternal nutritional status and food group consumption, but in 2013, increased consumption of vitamin A-rich fruits, eggs and bread, biscuits or cake were significantly associated with lower prevalence of thinness. There was no association between household FCS and maternal thinness (MoH 2015).

In 2013, it was found that only 18% of children (aged 6–23 months) achieved the minimum acceptable diet (MoH 2015; WHO 2010b), with 79% of children consuming an adequate number of meals but only 28% of children achieving adequate dietary diversity, a measure of individual dietary quality. Higher household FCS was significantly associated with higher quality diet in children (MoH 2015), though animal-source foods (ASFs) are one of the least-consumed food groups: about a quarter of children (aged 6–23 months) consumed eggs, dairy, meat or fish and in older children (aged 24–59 months) ASF consumption ranged between 11 and 31% (MoH 2015). A significant statistical association between ASF consumption and decreased levels of stunting was found amongst children aged 24–59 months (MoH 2015), indicating the importance of ASF in children's diets.

Animal-source foods are a significant contributor to the nutrient content of plant-based diets as they are rich in proteins and micronutrients that are highly bioavailable and readily absorbed and utilised, particularly *haem* iron and preformed vitamin A, and contain vitamin B12 which is rarely found in foods of plant origin (de Bruyn et al. 2015; Ianotti et al. 2017; Murphy and Allen 2003; Neumann et al. 2002; Schönfeldt et al. 2013; Wong et al. 2017). They are nutrient-dense, which is especially important for growing infants and young children (IYC) as they have small stomach capacities (Brown 1991; WHO 2009). In other regions, inclusion of ASF in the diets of IYC has been shown to decrease stunting rates, increase cognitive ability and educational attainment rates (Darapheak et al. 2013; Ianotti et al. 2017). Furthermore, utilisation of household's own livestock for ASF can increase household food security, particularly where rainfed subsistence agriculture is practiced and seasonal food shortages are common, as seasons have a less pronounced impact on livestock production than on crops (de Bruyn et al. 2015; Wong et al. 2017). Increasing consumption of ASF in Timor-Leste is a key component of current government strategies tackling undernutrition (RDTL 2016a).

Possible sources of ASF for home consumption include imported meats (usually frozen broiler chicken carcasses), local produce sold at market, meat, milk and eggs from the household's own livestock and undomesticated ASF sourced from fishing or hunting, which is legal for home consumption in rural areas of Timor-Leste. Although the consumption of buffalo milk from their own livestock was reported in Timor-Leste in the past, this practice stopped during the struggle for independence when large numbers of livestock were lost (Bettencourt et al. 2015). In 2002, a dairy was established at an agricultural high school in Lautem, but the harsh climatic conditions caused rapid deterioration of the equipment. The facility is now disused and there are no other facilities for producing pasteurised fresh milk in Timor-Leste. Several reasons explain why unpasteurised fresh milk is not consumed by households: (1) cattle, buffalo and goats in Timor-Leste largely graze on natural pastures—the nutritional quality of which may be low and vary greatly by season—and drink from natural water sources. A low level of nutrition and inadequate water supply would limit reproduction and milk production, making milk more likely to be reserved for feeding calves and kids (Waldron et al. 2016), (2) The cattle reared by households is an Indonesian beef cattle breed, rather than a dual-purpose or milking breed (Waldron et al. 2016), and may have inherently low rates of milk production; (3) The presence of *Brucella abortus*, a bacterium in buffalo and cattle that is transmissible to humans via unpasteurised milk (Davies and Casey 1973), may mean that the consumption of unpasteurised milk is not recommended or actively discouraged (Conceição 2012; OIE 2016); and (4) milk and dairy product consumption may not be the cultural norm in Timor-Leste. All in all, dairy consumption outside of the capital city, Dili, is low (Bettencourt et al. 2015; MoH 2015), and no published data are available on consumer attitudes. There has also been little published on consumer attitudes to imported poultry meat in Timor-Leste.

In 2011, AMSAT International found that in five municipalities, meats are infrequently consumed, and mostly saved for special events such as parties and ceremonies. Nationally, most ASF consumed by households are purchased (MoH 2015), despite high levels of livestock ownership (RDTL 2016b). While very few studies have explored the reason for low ASF consumption at the sub-national level, Bettencourt et al. (2015) found that in Bobonaro, consumption of their own livestock occurs at ceremonies only, when there are no vegetables, and when guests visit, with households generally reserving livestock as an important form of savings. Small animals—chickens, pigs and goats—are more commonly consumed, while buffalo and cattle are kept for prestige.

Fresh fish is most commonly purchased for consumption at coastal markets with limited availability inland due to lack of transport facilities, while some households purchase imported canned fish (AMSAT International 2011; MoH 2015). Inland sources of undomesticated ASF are rarely mentioned and have not been reported in any national surveys.

While food proscriptions and prescriptions are common and varied, they affect very small and specific portions of the population and are unlikely to influence nutritional status (Castro 2013). Qualitative data on intra-household distribution of foods, including ASF, report mixed results. There was no specific pattern in intra-household allocation of ASF within households in Baucau, Bobonaro, Covalima, Dili and Oecusse, or in Ermera and Liquica (AMSAT International 2011; Castro 2013). Nonetheless the MoH (2015) suggested that this may not however be the actual case given the patriarchal social structure in Timor-Leste.

This chapter examines several gaps in current knowledge, including factors preventing households from consuming their own livestock products, the nutritional importance of ceremonies where ASF is consumed and the use of undomesticated ASF in inland areas, and further investigates intra-household food distribution and the role of gender in food and resource access. It focuses on three municipalities. Although IYC consumption of ASF is extremely important for growth, an in-depth discussion of factors influencing IYC feeding is beyond the scope of this chapter, however improved household ASF consumption may also benefit IYC. While all sources of ASF are considered, there is an emphasis on village chickens and eggs, as chicken meat is preferentially consumed in Timor-Leste, chickens are the most numerous livestock in Timor-Leste (AMSAT International 2011; RDTL 2016b), and because the research was linked to a village chicken vaccination program (Jong 2016). By understanding the limitations on households' utilisation of their livestock assets, policies, programs and findings can be directed towards addressing these issues.

14.1.1 Study Setting

Timor-Leste is a small, half-island nation nestled at the eastern end of the Indonesian archipelago just north of Australia. A Portuguese colony for 450 years, and then under Indonesian occupation for 24 years, Timor-Leste had a long and violent struggle towards independence in 2002. The Catholic Church played a significant role during this difficult period, and the majority of Timor-Leste's population identify as Roman Catholic, though most practice Christian beliefs alongside inherited animistic cultures. Many households have Christian altars within their homes and construct traditional houses in which their ancestors are venerated (Traube 1980). In parallel with national government laws and the health system, people often observe local laws (*Tara bandu*) governing the use of water, wild forests and animals, and sacred areas, and consult with traditional healers when sick (Cardinoza 2005; McWilliam 2001).

Timor-Leste is a demographically young nation, with 39% of the population under 15 years old, and 8% over 60 years (RDTL 2016c). The majority (84%) of households are male-headed, and average rural household size is 5.5 (RDTL 2016d). The fertility rate of rural women is 6.0 (NSD et al. 2010). In 2009–2010, almost half of all rural households were in the lowest two wealth quintiles of Timor-Leste, and 72% of women and 78% of men were engaged in agriculture (NSD et al. 2010). Maize, rice and cassava are the main staple foods of Timor-Leste, with 83% of farming households growing maize as a major crop (Andersen et al. 2013). Timor-Leste experiences a hot tropical climate with distinct rainfall periodicity. Most farmers produce one staple crop per year, and small crops of fruits and vegetables (Andersen et al. 2013). In 2015, 87% of all households in Timor-Leste owned livestock, with 82% of these households owning both chickens (average 6.4 per household) and pigs (average 2.9 per household), 30% owning cattle (average 4.25 per household) and 26% owning goats (average 3.4 per household) (RDTL 2016b).

This study was undertaken in three municipalities of Timor-Leste: Aileu, Bobonaro and Lautem. Data disaggregated by municipalities from 2013 (MoH 2015) show high levels of house (range 86–87% of households) and land ownership (86–99%) across all three municipalities, with a similar percentage and range of households using unimproved sources of drinking water (28–35%) and having unimproved sanitation (47–55%). There are differences between the municipalities in primary carer education and literacy levels, with highest levels of primary carers with no education (40%) and illiteracy (44%) in Bobonaro, and the lowest levels of primary carers with no education (23%) and illiteracy (24%) in Lautem (MoH 2015).

Disaggregated nutrition data (Table 14.1) show that the percentage of households achieving acceptable food consumption scores is similar across the municipalities, ranging from 65–73% of households. Lautem has lower rates of underweight in non-pregnant women and stunting in children (aged 24–59 months), but children in Aileu were more likely to achieve adequately dietary diversity (MoH 2015).

14.2 Materials and Methods

This study was undertaken as part of the Timor-Leste Village Poultry Health and Biosecurity Program (VPHB), an Australian Government-funded program implemented in 2014–2017. One of its primary aims was to improve village chicken production, largely through community-based control of virulent Newcastle disease (ND) (Alders and Spradbrow 2001). The VPHB ND vaccination programme was piloted in three villages selected on the basis of criteria outlined in Table 14.2: Pairara Village in the east, Hautoho Village in the centre and Saburai Village in the

Table 14.2 Criteria for pilot village selection

Level	Criteria
Country	• One village on the border between Indonesia and Timor-Leste • One village from the central region • One village from the eastern region
Municipal	• High incidence of stunting and wasting • Potential to produce maize beyond household and community needs • Accessible to the National Veterinary Laboratory • Secure • Existence of complementary programs, for example, home gardens or fish ponds • Access to market • Majority of households raising chickens • Reports of outbreaks of disease over 80% chicken flock mortality at least once per year
Village	• Keen interest in production of village chickens • Implementing Ministry of Health SISCA (*Serviço Integrado da Comunidade*) program with monthly measurement of the length, weight and mid-upper arm circumference of both children up to the age of 2 years and pregnant women • Active Ministry of Agriculture and Fisheries livestock technicians and agricultural extension workers • Good co-operation between local government and the communities, as well as with the Ministry of Agriculture and Fisheries at the municipal and administrative post level • At least 20 family groups willing to participate in the program • SISCA and Ministry of Agriculture and Fisheries livestock personnel willing to collaborate • Well-respected and supported local leader (e.g. elected two times or more) • Easy access in wet and dry seasons • Ready to implement program if selected

Table 14.3 Overview of activities in pilot villages

Data	Participant	April–June 2015	October 2015	February 2016	April–June 2016	October 2016	February 2017	April–June 2017
		Less-rainy	Dry	Rainy	Less-rainy	Dry	Rainy	Less-rainy
Quantitative								
Maternal dietary diversity	Primary adult caregiver (most often the mother) for enrolled child, <24 months of age at commencement of study	✓	✓	✓	✓	✓	✓	✓
Qualitative								
Key informant interviews	Village leaders, doctors and elders, and municipal agriculture and nutrition staff	✓			✓			✓
Focus group discussions	Mothers, fathers, vaccinating and non-vaccinating households	✓			✓			✓
Participant—observation	Inhabitants of study villages	✓	✓	✓	✓	✓	✓	✓

west of Timor-Leste (see Fig. 14.1). The present study sought to investigate possible associations between improving village chicken health and maternal and child diets and nutrition. It was implemented in collaboration with the Timor-Leste Ministry of Agriculture and Fisheries, and the Ministry of Health, and collected qualitative and quantitative data from these villages between April 2015 and June 2017 (Table 14.3). For the quantitative data, households with at least one child under 24 months of age were recruited, and the youngest child and his/her mother were enrolled in the study. Dietary data were collected using a 24 h recall period and a multiple-pass method (Blanton et al. 2006), and dietary diversity scores calculated using the Minimum Dietary Diversity for Women (MDD-W) (FAO and FHI 360 2016), and the Infant and Young Child Feeding Minimum Dietary Diversity (IYCF-MDD) (WHO 2010b) indicators. Summary statistics were produced using Microsoft Excel. Qualitative data were collected using key informant interviews and focus group discussions. Key informants included village leaders, cultural leaders and Ministry of Health staff members, with 12 interviews being conducted in total. Focus group discussions were gender-disaggregated (see Table 14.4). Some 47 focus groups were conducted with different research themes explored in different discussions. The methodology is described in greater detail in the previous version of this chapter (Wong et al. 2018).

Initial key informant interviews identified three seasons: a less-rainy season from April to July, a dry season from August to October and a rainy season from November to March. Initial adult and child dietary diversity data were collected in April to June 2015. A total of 203 pilot village households were enrolled, consisting of 64 house-

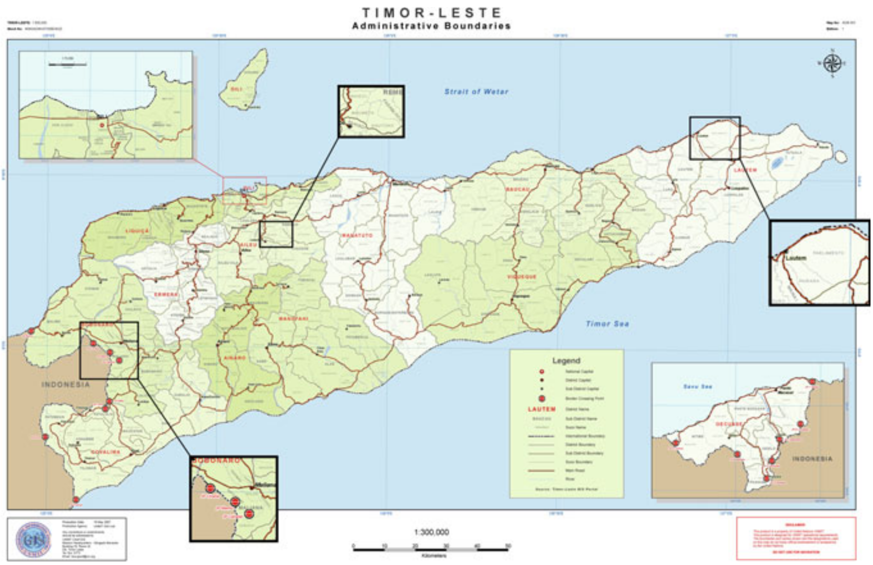

Fig. 14.1 Timor-Leste. Study sites and villages highlighted and enlarged. Adapted from UNMIT GIS (2007)

holds from Hautoho, 70 from Saburai and 69 from Pairara. Ninety-seven percent of survey participants were mothers, two percent grandmothers and one percent fathers. As the majority of participants were women of reproductive age (15–49 years), all adult dietary diversity data was analysed using the MDD-W (FAO and FHI 360 2016).

14.3 Results

In all three villages, both adults (Fig. 14.2) and children (Fig. 14.3) had high rates of consumption of grains and starchy staples, and moderate to high consumption of dark green leafy vegetables and other vitamin A-rich fruits and vegetables. Amongst participating adults, there was no consumption of fresh or powdered milk, yoghurt or cheese. Amongst all the participants, the only foods consumed containing milk powder were infant formulas, and as this is counted as ASF consumption, this has been included in this representation of foods consumed (Fig. 14.3).

Quantitative baseline data from the dietary diversity dataset found stark differences in ASF consumption between villages, with 48% of mothers and carers in Pairara consuming ASF in the previous 24 h, compared to 6% in Hautoho (Fig. 14.4). More detailed exploration of ASF consumption (Fig. 14.5) shows that eggs are the most commonly consumed ASF amongst both adults and children. Fish are more commonly consumed in Pairara, and non-domesticated animal species were only consumed in Pairara.

In examining the food consumption data from the 2013 Food and Nutrition Survey (MoH 2015) and the 2009–2010 DHS (NSD et al. 2010), the differences between the municipalities of Aileu, Bobonaro and Lautem were not as pronounced as the respective differences between Hautoho, Saburai and Pairara villages. Prominent

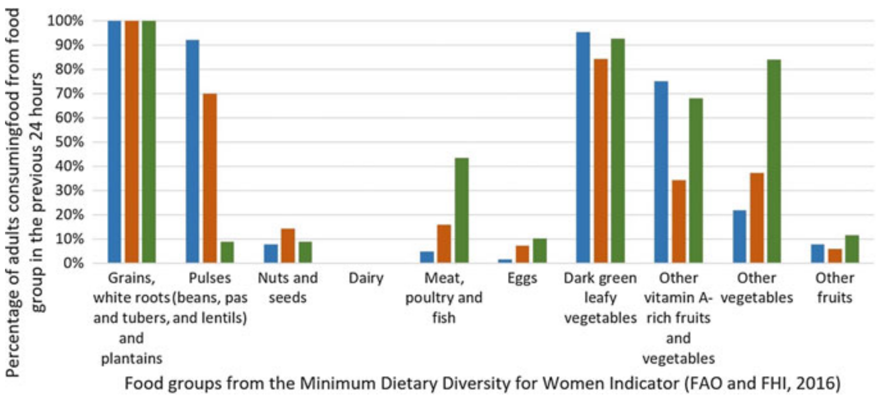

Fig. 14.2 Food group consumption of participating mothers and carers aged between 17 and 58 years, based on a 24 h recall period. Data collected at baseline (April–June 2015, less-rainy season)

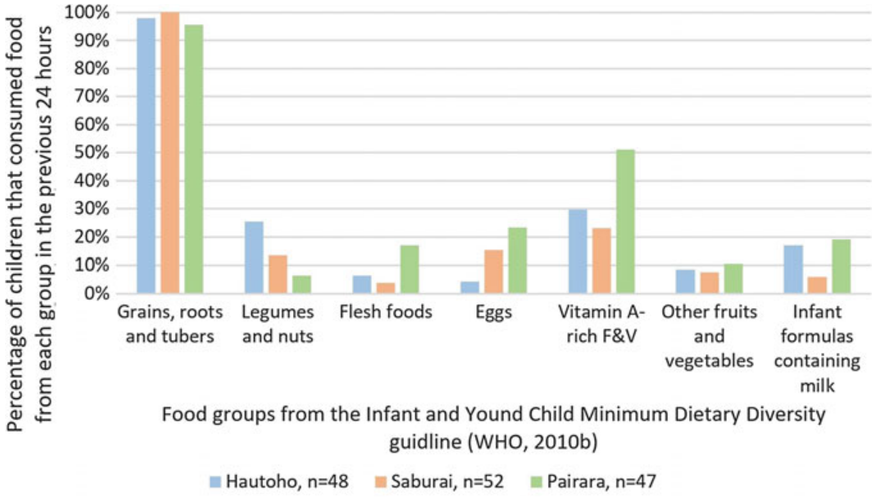

Fig. 14.3 Food group consumption of children aged 6–24 months, based on a 24 h recall period. Data collected at baseline (April–June 2015, less-rainy season)

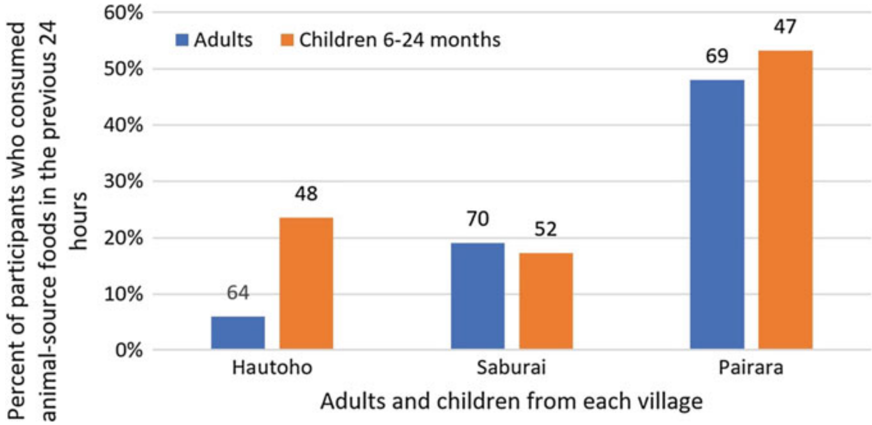

Fig. 14.4 Percentage of participating mothers and carers aged 17–58 years, and children aged 6–24 months consuming any animal-source food (ASF) at baseline (April–June 2015, less-rainy season)

themes that emerged from the qualitative study in the analysis of factors influencing consumption of ASF were availability, access, sociocultural practices and women's decision-making power.

Table 14.4 Focus group discussion participants

	Characteristic of participants	No. of FG	No. of men	No. of women	Total
2015					
Hautoho	Women	2		19	19
	Men	1	8		8
Saburai	Women	2		13	13
	Women, owns chickens	1		8	8
	Men	2	14		14
	Men, owns chickens	1	8		8
Pairara	Women	2		19	19
	Women, owns chickens	2		15	15
	Men	1	5		5
	Men, owns chickens	2	17		17

(continued)

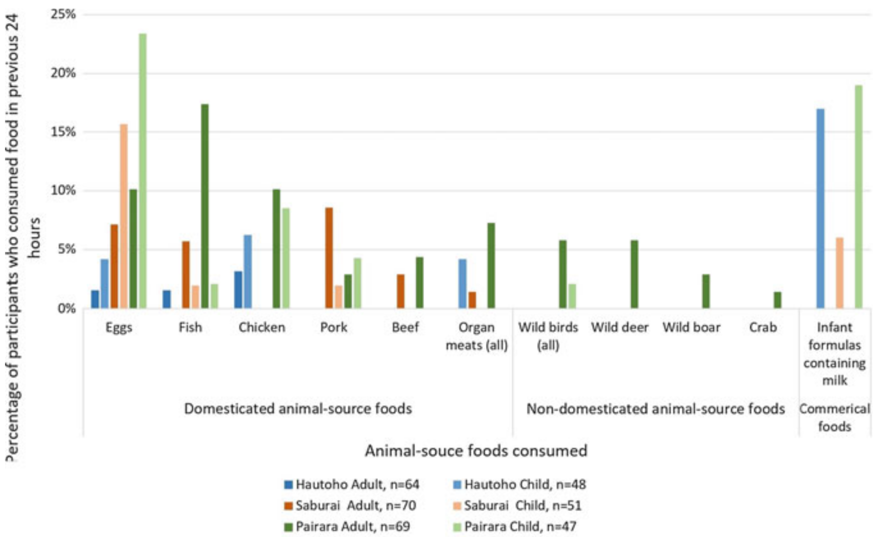

Fig. 14.5 Types of animal-source foods consumed by adults aged 17–58 years and children aged 6–24 months at baseline (April–June 2015, less-rainy season)

Table 14.4 (continued)

	Characteristic of participants	No. of FG	No. of men	No. of women	Total
2016					
Hautoho	Women	3		17	17
	Men[a]	1	7		7
Saburai	Women[a]	1		4	4
	Women, vaccinating	2		10	10
	Women, not vaccinating	1		5	5
	Men, vaccinating	3	14		14
Pairara	Women[a]	4		26	26
	Women, vaccinating	1		7	7
	Men[a]	1	7		7
2017					
Hautoho	Women	2		15	15
	Women, not vaccinating	1		4	4
	Men	1	3		3
	Men, not vaccinating	1	6		6
Saburai	Women[a]	2		12	12
	Men, vaccinating	1	6		6
	Men, not vaccinating	1	6		6
Pairara	Women, vaccinating	2		12	12
	Women, not vaccinating	1		11	11
	Men, vaccinating	1	6		6
	Men, not vaccinating	1	8		8
Total		47	115	197	312

[a]Denotes that one group was a convenience sample
FG = focus groups. 'Women' include mothers, grandmothers and women of reproductive age (15–49 years); 'men' include fathers, grandfathers and adult men; 'vaccinating' refers to vaccinating chickens against Newcastle disease

14.3.1 Availability of ASF

Most villagers stated that they liked to eat all types of ASF and would consume more if it were available. Chickens are the most abundant livestock species in Timor-Leste, and chicken meat the most commonly consumed ASF, but problems existed with the availability of their own chickens and eggs. For chickens, disease and predation were major limiting factors for consumption. Due to ongoing losses, remaining chickens and eggs were reserved to allow the flock to perpetuate. When participants have few chickens, they are reserved for emergency use only, and regular consumption within the household does not occur—*I want to eat my own chickens, but there are not* *enough chickens* (Hautoho, male, 2017). However, when there are more chickens, male and female participants mentioned that they give the eggs to the children to eat. In the dry season when chicks are more likely to be lost due to predation, or when there are a lot of eggs, adults also eat the eggs. If participants had many chickens, they would eat chickens and eggs with much greater frequency—*If the [wild] cat does not eat them, and the chickens are not dying, why not eat them?* (Saburai, male, 2015) and *If we have a lot of chickens, we can eat chicken and eggs whenever we feel like it*, (Saburai, male, 2017). As chickens are valued household assets, participants prioritised sale over consumption, but explained that if they had enough chickens, they would sell some, eat some and reserve some for ceremonies.

Fish was observed to be one of the most commonly consumed ASF in Pairara village, which is both closest to the coast and has the easiest terrain to traverse. In Pairara, fishermen or traders regularly come by motorbike to sell fresh fish in the village, or villagers could travel to coastal markets. In Saburai village, fresh fish is sometimes available in the regional market about one hour away, and villagers require transport to be able to purchase, and in Hautoho, fresh fish is purchased from Dili, almost two hours away. Dried, salted fish is sometimes available in regional markets, while canned fish (mostly tuna and sardines) is usually available from kiosks within the villages. Fish ponds, where households raise their own fish in stand-alone or mixed farming systems, are not common in any of these three villages.

Undomesticated species are also an important source of ASF. Hunting was mentioned by both male and female participants, but is an activity undertaken by boys and men only. Participation in hunting was dependant on whether the activity was allowed in their village, whether the village was close to forested areas, and the motivation and skill of hunters. In Hautoho, local law (*tara bandu*) prohibits hunting, and most participants asked about hunting in this village stated that people there do not hunt. In contrast, hunting is permitted in Saburai and Pairara villages, and men were frequently observed on their way to or from the forest in both villages. In both villages, almost all participants who discussed hunting confirmed that people within the village hunt. In Pairara village, it was common for boys and men to hunt, and for children to walk through the streets of the village selling the carcass.

For participants who said that people in their village hunted, or that people came to sell animals sourced from hunting in their village, the species of animal was determined (Table 14.5). Hunting is more common in Pairara, where a greater variety of undomesticated animals inhabited nearby forested areas.

14.3.2 Value of Livestock and Economic Access to ASF

Livestock are often not functionally accessible to households for general consumption as they are reserved for sale or ceremonies—*All of the community here keep many animals, but they cannot eat them because they get money from these animals*, said one man in Saburai (2015). Another man summarised it as *eating meat is like eating money* (Saburai, 2015). Because livestock have high monetary value, villagers

Table 14.5 Undomesticated animal species contributing to animal source food availability

Species, English–*Tetun*	Hautoho	Saburai	Pairara
Bat–*niki*			1
Civet cat–*laku*	1		3
Cuscus–*meda*		2	4
Deer–*rusa*	1	1	5
Jungle fowl–*manu tafui*		1	
Monkey–*lekirauk*		1	3
Pigeon–*manu pombu*			1
Python–*fohorai*			2
Turtledove–*lakateu*			1
Wild bird–*manu fuik*			4
Wild boar–*fahi fuik*	1	2	7
Wild buffalo–*karau fuik*		1	
Wild cat–*busa fuik*	1		
Total no. species	4	6	10
Total no. of mentions	4	8	31

often prefer to conserve their own animals and purchase meat when they wanted to eat it: *We just buy [frozen imported chicken] to eat. We will kill our own chickens during good times, like for cultural ceremonies—then we will kill and eat our own chickens. But normally, if we want to eat chicken meat, we buy [frozen imported chicken] from the market. We don't just eat our own chickens any time* (Saburai, male, 2017). The value of local chickens (US$ 5–12 in June 2017) is much higher than the cost of frozen imported chicken (US$ 3–3.50), so households can sell their own chickens and use some of the money for both household needs and purchasing frozen chicken. Households sell their chickens within their villages, to households that required a chicken for a ceremony, or wealthier households that could afford to purchase them for consumption. Chickens are also sold on the roadside, at regional markets or to traders who transported them to town for sale.

Villagers stated that although ASF is highly valued as food, many people could not afford to consume it; people would prefer to consume more ASF, including milk from ruminants, if they had more money or a higher status:

Rich people have a lot of money and they can buy good food like meat, fruit and whatever else they want to eat. They can buy meat like beef, wild boar, venison, pork and chicken. People who are poor eat bad food, only corn, yam and cassava. Sometimes people sell meat but it is very expensive and [poor people] cannot buy it because they do not have money. They want to eat this, but because they are poor, they do not have the money to buy it, (Pairara, female, 2015).

We only buy milk when we have a lot of money, or when we are sick. We do not have a lot of money to spend because our income is very small. However, when we are sick, we need good foods to improve our health, like meat, milk and fruit. We know *that these foods are good for health*, (Saburai, male, 2016). Participants explained that they knew these foods were good for health because it was explained by doctors and nurses at the health posts and clinics.

Livestock are usually sold for a specific reason, such as to cover educational expenses, pay for ceremonies, or to purchase food items, with smaller species sold first: *When there is less food, people sell chickens, goats, pigs, and buffalo to buy food to eat. First, they sell the chickens and buy food. When they do not have food again and have no more chickens, they also sell large animals*, (Pairara, female, 2015). Staple foods are prioritised—when asked what foods people buy with the money after selling livestock, male and female participants most commonly listed rice, oil, sugar, salt and seasoning. If money was left over, women said that they would buy other foods including ASF. If there was no money, they said they would just eat plain rice, plain rice with chilli, or rice with the vegetables grown by the household. People only go to market to buy ASF if they had something to sell: *We like meat, eggs and fish, but it depends on money. If we bring vegetables or something to sell in Dili, then we can buy meat, eggs and fish. In the rainy season, we can grow more vegetables, sell more and buy more food. In the dry season, it depends on the production of mustard greens and Chinese cabbage and if we are hardworking,* (Hautoho, female, 2017). Even to improve the diet of their children, households cannot always buy the recommended food. *For food, we hear information from the doctor and health staff about what foods are good for children. But we don't always follow this advice if we have no money* (Hautoho, female, 2017).

A difference exists between ASF from slaughtered and consumed livestock and that which is purchased: micronutrient-rich organ meats are always consumed when livestock are slaughtered at home, but rarely purchased. Organ meats were sometimes available for purchase at markets, however, they were chopped, mixed and partially cooked to prevent malodour and sold as small plated portions. Most people stated that they like to eat organ meat as it is tasty, but when discussing preferred parts of the animal to buy, participants invariably said that they only purchased meat, not the organs. Normally organs were not available for sale, because the household who slaughtered the animal normally keeps the organs for their own consumption, or they buy frozen imported chickens that only contain meat and bone. Although organs are available for purchase and are cheap, people only buy them if they had money left over after buying meat, and that they prefer to purchase meat because they have no refrigeration to store organ meat.

Lastly, it is common for households to consume ASF when livestock become ill or die from unknown causes. Most people said that they would slaughter sick chickens for consumption or eat a dead chicken if it still looked fresh and did not smell. Chickens that had died did not have the same flavour and were not as pleasant to eat as healthy chickens, however, it was seen as wasteful to throw the carcass away: *We ate the dead chickens, but they were not tasty. We had kept the chickens until they were big already, so it didn't feel good to throw them away*, (Hautoho, male, 2017). When discussing the impact of the Newcastle disease vaccination program, one man stated that *some people wait until the chicken has died and then they eat it; others kill and eat the chicken when it looks very sick. Now that the chickens* *are not dying, we don't have to do this as much*, (Saburai, male, 2016). One man (Saburai) stated that if one or two chickens die, they can just be thrown away, but if many chickens die, it is a waste if they do not eat them. Another preferred not to eat dead chickens since disease could infect humans. Others, who stated that they did not like to consume dead chickens themselves, said that they sometimes gave them to children or neighbours to eat.

14.3.3 Sociocultural Practices

In Timor-Leste, social custom, ceremonies and rituals are intertwined with everyday life, and vary by region and language group; they may be performed within households, or involve the wider community. Social events and Christian ceremonies were celebrated in all three villages, and were the most commonly cited occasion for the consumption of ASF: in some group discussions in Saburai, participants noted that ceremonies were the only occasion when people consumed ASF. Social occasions involving the consumption of ASF include birthday celebrations for children and adults, graduation from university, parties, New Year celebrations or family members visiting from afar. Christian ceremonies include the Baptism (*Sarani*), Confirmation (*Krizma*), All Soul's Day (*Finadu*), Christmas and weddings. Funerals are always accompanied by ASF consumption, with ceremonies a combination of Christian and animist rituals. While social and Christian ceremonies were common across the three villages, there was great variation between the villages in the number of animistic ceremonies observed (Table 14.6), and their duration. There were no restrictions on the consumption of ASF for these events generally or by age, gender or socioeconomic status. In ceremonies involving the whole community, food was placed on a communal table, and each person lined up to take the quantity of food they wished to eat.

Not all animistic ceremonies require animal sacrifices of chickens, pigs, goats or cattle; other offerings include eggs, maize, tobacco and betel nut. Ceremonies involving the wider community involve killing and eating multiple animal species, while ceremonies within households more commonly use smaller livestock including chickens and their eggs. The cultural leader (*lia nain*) advises on the appropriate location, time, words, process and roles of individuals. Where animal sacrifices are involved, blood may not be available for consumption because of specific slaughter techniques or its being part of the ritual, though the remainder of the carcass is available. Where chickens or eggs are used, they must only be from local breeds. Ceremonies using eggs may require the eggs to be left in sacred places such as under a revered tree or rock, placed in a symbolic location such as on a road, or opened onto a plate and examined.

A number of different village ceremonies required an animal sacrifice. Ceremonies for members of the household who were ill was the most common in all three villages. Following these, rituals surrounding construction, especially that of sacred buildings such as traditional houses (*uma lulik*) or clan houses (*uma lisan*)

Table 14.6 Animistic ceremonies performed in Timor-Leste involving the consumption of animal-source foods

Ceremonies involving ASF consumption	No. of times ceremony mentioned		
	Hautoho	Saburai	Pairara
Illness and death			
Traditional X-ray, used to diagnose cause of illness			X
To cure or relieve illness	X	X	X
To find cause of death			X
Death	X		X
Ceremonies 1-2 weeks after burial (*ai funan*)	X		
To mark the end of mourning (*koremetan*)	X		X
As a gift to ancestors (*matebian*)	X		X
Construction			
Building or inauguration of a sacred house (*uma lulik, uma lisan*)	X	X	X
Building a tomb, grave	X		X
Other forms of construction		X	X
Agriculture			
Sowing crops		X	
Harvesting corn	X	X	
Ceremony "washing the eyes of cattle"	X		
Birthday celebration for cattle	X		X
Offering for sick cattle			X
Fortune telling or divination			
To find a lost person		X	
To call the soul back when it is lost		X	
To see how someone living far away is doing		X	
To see what life in future holds			X
Detecting gender of foetus			X
Offering to the sacred tree			X
To see the outcome of war			X
Determine luck for a specific situation			X
Household			
Annual offering for household health			X
To resolve a quarrel in household		X	
Successful negotiation of bride price (*barlaki*)			X
Forgiveness			
Assuage guilt for wrongdoing		X	
For having killed a snake		X	

were the next most common (Table 14.6). Hautoho, the village with the lowest ASF consumption, also had the smallest number of ceremonies. More ceremonies were practiced in Pairara, the village with the highest level of maternal ASF consumption. There was a marked difference in the duration of ceremonies between villages. Thus, when there is a death in the village, animals are always sacrificed in honour of the person's spirit—*We always eat meat when people die—whether you like meat or not!* (Pairara village, female, 2016). The *lia nain* advises family members on the number of days for the ceremony, how many animals would be required and which species should be brought by which family members. In Hautoho and Saburai villages, these ceremonies generally took place over 1–3 days, however in Pairara village, ceremonies lasted for a week or more. In the dry season, when there were more ceremonies, the periods of time in which households can consume ASF may start overlap or run consecutively, resulting in almost daily consumption.

Consumption of ASF at ceremonies may also be prescribed. In Hautoho, when a person dies, family members from the wife's side can only consume ASF from cattle and goats, while family members from the husband's side can consume ASF from pigs only. Guests at the ceremony who are not family members are able to consume any ASF. This differs from cultural norms in Saburai, where any participants, family members or not, can consume any ASF at the ceremony.

Aside from social events and ceremonies, another common practice that enables community members to consume ASF is sharing amongst the local community. It is not uncommon for villagers to eat ASF because they have received it as a gift from extended family, friends or neighbours.

14.3.4 Gender and ASF Consumption

14.3.4.1 Food Distribution

Women, generally the mother of children in the household, are responsible for meal planning and food preparation, with workload shared between the mother and teenage daughters: *It is always the mothers who cook. Mothers decide what to eat each day. It is always the mothers that distribute food to the rest of the family, although the eldest daughter can also help if she is not at school* (mother from Hautoho). Most of the time, mothers allocate household food, so that everyone gets a fair share and there is enough food for everyone. Either food is placed on the table and everyone in the household eats together, or less frequently mothers will plate food for the children but food is placed on the table for adults to eat together. Men and women consider that food, including ASF, is distributed evenly within the household. One person from Pairara stated: *Now, here, there is no difference between males and females in how people eat food in the family compared to past times during colonialism*. One mother from Hautoho said: *It is the mother [of the children in the household] who decides how much food to put on each plate, but for all family members that are already adults, the amount of food must be equal. If one plate has more or less food, the person will shout* *that it is not equal. All adults should be equal.* Another mother in Pairara explained: *The mother always distributes food for each person in the household, people do not choose themselves. We do this because if they choose food for themselves, they may not finish all the food and they will waste it, or some people will eat more. We need to make sure everyone has enough to eat.* Repeated observations indicate that this is the norm, and that, before serving, mothers have already apportioned the food, ensuring that the dishes are equitably shared. Where there is a lot of food, each dish is placed on the table and each person serves themselves the amounts of staple food and side dishes as they would like. Where particular dishes are limited, portion sizes of similar appearance are distributed to each adult, and smaller portions of side dishes are distributed to each child. There were no restrictions on any particular ASF for particular groups of people.

Circumstances changed when there were guests. Rice was served to the men and guests, and women and children ate maize and beans instead. Mothers explained that guests preferred to eat rice, and that it was considered a higher status food. Although the rice was abundant, the women and children said that they preferred to eat maize sometimes if they had been eating rice a lot recently, because it is tasty, filling and is their traditional food. Sometimes after the guests leave, men will also eat a bowl of maize.

Although the distribution of food within households is considered by participants to be equal, outside of the household, there may be more opportunities for men to consume ASF than women. Only men ate meat during some ceremonies, and some ceremonies for inaugurating clan houses (*uma lisan*) only involved men: *For this ceremony, the women do not eat the meat, the men eat it. Female and male children also do not eat. Even an 80-year-old woman cannot eat the meat, because this is tradition. If a woman eats the meat, she can become sick or go crazy* (Pairara, female, 2016). By contrast there are no ceremonies where only women can consume the ASF. All ceremonies observed by the researcher involved both men and women, and there was no restriction on women's consumption of ASF.

In Hautoho at least, men sit together about once a month, to chat, drink alcohol and consume ASF. It is common for food to be consumed while drinking alcohol and ASF is preferred, however, it is only accessible if the men have enough money to purchase it. Sitting together, drinking alcohol and consuming ASF was also only practiced by men. Women's social time sometimes involved active tasks such as fetching water or weaving, often accompanied by sharing of betel nuts, but never alcohol and ASF.

14.3.4.2 Decision-Making Ability

Chickens can be owned by anyone in the household. Usually all members of the family look after the chickens, depending on who is available, but in some households only women look after the chickens. Women and children play a bigger role in caring for chickens, while men play a bigger role in caring for larger livestock.

In deciding when to use animal assets, it is rare for women to make autonomous decisions. Husbands and wives decide together whether chickens are sold or not. Occasionally men, but not women, make independent decision to sell chickens, unless there is need within the household. One woman in Pairara, however, stated that *we can sell piglets, goats and chickens—small animals. We decide to sell them ourselves and buy what we like with the money*. More commonly, when husbands and wives decide together to sell livestock, they also decide what the money will be spent on. Pairara was the only village where women said that they are able to make the decision to slaughter a chicken for household consumption. These observations about the difference in women's autonomy and agency between villages matches other observations: at the start of research, Pairara was the only village with a female in a prominent leadership position, and in the selection of field team members, the Pairara village chief was strongly supportive of gender balance.

Women attach greater importance to keeping chickens for consumption and for purchasing foods that increase dietary variety, while men emphasised keeping of chickens mainly for income generation. Both men and women stated that they would use the money from selling chickens to buy household staples, such as rice, oil, salt, sugar and seasoning. Females more commonly stated that they would use the money to purchase different vegetables, ASF and children's school needs, while a larger proportion of men listed expenses such as ceremonies, alcohol, tobacco, cigarettes and business needs. In Saburai, men listed the following items they would purchase with money earned from selling chickens: *We always buy tobacco, betel leaf and areca nut. Then we buy cigarettes. Then books, pens, shirts and pants. Then rice and oil. Then coffee and sugar. Lastly, we also use some for cultural ceremonies.* In the same village, females stated that when they sell chickens, they would buy *things for school like books, pens and clothes. Foods like rice, food from other people's fields. Occasionally we buy fish or meat. We buy moisturiser and deodorant. We also buy betel leaf and areca nut, oil, salt, sugar and coffee.* The sentiment that chicken ownership was only important for income generation was expressed most strongly by one man, who stated: *If you have a chicken program, you need to work with people to buy chickens, otherwise you raise chickens just to die, or to eat! What's the point—only eating the chicken, or to be able to sell it?* (Pairara, male, 2017). In his opinion, a program to improve chicken production would only be successful if you could sell the chickens; raising chickens for consumption was not a valued end-point.

14.4 Discussion

The most important constraints on household consumption of ASF are low numbers of small livestock, limited household income and the low decision-making ability of women, leading to decreased prioritisation of household nutrition. For the three villages, no food proscriptions or prescriptions specific to everyday consumption of ASF exist and people would have liked to eat more ASF. Increasing the numbers of healthy livestock might provide a stable source of ASF to households, but livestock ownership does not necessarily increase ASF intake. Large livestock are kept more for status, savings and ceremonies, while small livestock species are more likely to be sold for households needs including food or consumed at home (AMSAT International 2011). This is somewhat similar to Uganda, where poultry ownership increased household chicken consumption, goat and sheep ownership did not increase goat and sheep meat consumption and cattle ownership did not increase beef consumption but was associated with increased milk consumption (Azzarri et al. 2015). In Timor-Leste, fresh milk is rarely consumed, so while the occasional sale of large livestock (cattle and buffalo) is an important income source for some households, ownership of large livestock does not contribute regularly to household nutrition. Moreover, disease and predation are major limitations to production of poultry and goats, and small flock or herd sizes decrease the likelihood that households would use their own livestock. These are important considerations for food and nutrition security, where agricultural programs should aim at improving health and husbandry, by targeting smaller livestock species such as chickens and pigs.

Women in Timor-Leste rarely make autonomous decisions or own small livestock and, more generally in Timor-Leste, women take a more subservient role in decision-making (Scantlan and Previdelli 2013). This study finds that when women are able to decide what to buy, their income is more likely to be spent on improving dietary diversity, and livestock under the control of women are more likely to be used for household consumption than sale. This is similar to that in other parts of the world, such as Kenya where, when livestock were owned by women, there were positive impacts on nutrition and child growth, since they used a greater percentage of resources to improve household nutrition and health (Jin and Ianotti 2014). A large body of evidence points to women's empowerment in agriculture leading to better dietary outcomes for households (Malapit and Quisumbing 2014; Ruel et al. 2013; van den Bold et al. 2013), although studies examining the relationships between women's empowerment and child nutritional status have produced mixed results (Cunningham et al. 2015a). Smith et al. (2002) found that women's relative household decision-making power had a strongly positive effect on child WHZ and HAZ in South Asia and sub-Saharan Africa, but a positive effect on child WHZ only in Latin America and the Caribbean. In South Asia, financial autonomy has both been positively (Shroff et al. 2009) and not significantly (Shroff et al. 2011) associated with stunting in Andhra Pradesh (India), while in Nepal, a positive association was found between maternal decision-making power in daily household purchases and child WHZ, but the association was negative with large household purchasing decisions. Using the Women's Empowerment in Agriculture Index (WEAI)'s Five Domains of Empowerment (5DE), Cunningham et al. (2015b) found that child LAZ was significantly associated with overall women's empowerment, but no significant associations occurred between child LAZ and major household asset ownership, or the ability to purchase, sell or transfer productive assets. These findings contrast with that in Papua New Guinea, where asset ownership by mothers was found to be significantly and positively associated with child HAZ and WHZ in van der Meulen Rodgers and Kassens (2018). These mixed results suggest that relationships between women's empowerment and child nutrition outcomes are complex, with environmental, economic and cultural influences likely affecting the significance of different domains of women's empowerment.

Nonetheless sound national policies and programs that address women's empowerment are invaluable. Women are more likely to use their livestock for household consumption or mobilise their assets to support household nutrition, and should have the same access to programs, extension services, information and technologies as men, enabling them to produce livestock more efficiently. Programs promoting the production of livestock under the control of women, particularly when extensive and semi-intensive production systems are employed, have the potential to make great contributions to household nutrition and improve women's status without considerably increasing their workload. In Mozambique, participation in a Newcastle disease vaccination program allowed women to sell four or five chickens and buy a goat, with the ultimate aim of selling some goats to buy cattle, increasing their economic autonomy as well as self-esteem and confidence (Bagnol 2001). Integrating such programs would encourage nutrition behavioural change and a greater impact on child nutrition.

Economic constraints were raised by participants as a major barrier to ASF consumption. As household income increases, utilisation of livestock as ASF increases (Delgado 2003). Here, most participating households value ASF and produce livestock, but poorer households need to sell the livestock for income, while wealthier households, including households that do not produce livestock, can afford to consume or purchase it. Policies aimed at improving economic opportunities would benefit any households living at or below the poverty line, while policies aimed at improved household nutrition must also consider income generation. Positive nutritional shifts are otherwise unlikely, as here, where nutrient-dense foods including ASF are more expensive, and fat- and sugar-rich processed foods are cheap, tasty and readily available at many small kiosks in the villages.

Although increased ASF consumption is nutritionally beneficial, the risks of poor food safety, emerging infectious diseases and loss of biodiversity pose problems (Golden et al. 2011; Jones et al. 2008). Consuming animals that have died from undiagnosed illnesses, out of necessity when people have scarce resources, increases the risk of transmissible diseases such as avian influenza (Alders et al. 2013). Non-domesticated animals can contribute significantly to diets, but the encroachment of human activity into forest areas increases the risk of disease, and puts pressure on wild populations, potentially reducing sustainability and threatening local food security and biodiversity. Supporting household livestock production may decrease these risks to human health and biodiversity.

Elsewhere in Timor-Leste, as here, ceremonies and social events are the most common time for people to consume ASF. Another study found that 89% of people in Baucau, Bobonaro and Covalima municipalities ate ASF at traditional ceremonies, while 29% ate ASF every day (AMSAT International 2011). In addition to fulfilling social and cultural expectations, animal sacrifices at community events enables households to display socioeconomic status, and to reduce inequality by distributing wealth in the form of ASF (Castro 2013). Additionally, sharing of ASF between households, whether associated with a ceremony or not, may reflect limited storage options for ASF in villages, but also reinforces social networks and builds social capital. However, there are vast differences between different Timor-Leste municipalities in the frequency and duration of ceremonies. Where many ceremonies are lengthy and even overlap, frequency of ASF consumption increases to a level significant enough to contribute to improved nutritional status, although this effect may be seasonal, and otherwise ceremonies and social events may be too sporadic to contribute to nutrition.

Men participate in more social or ceremonial events involving ASF consumption outside the household than women, but within the household, there was no 'channelling' of ASF to men, however quantitative measures were not made, observation occurred at times of sufficient food and people may not have been comfortable reporting preferential treatment. Despite these limitations, this is similar to that reported elsewhere in Timor-Leste, where just a few older members of households and household heads received more (AMSAT International 2011), but in contrast to South Asia especially where high-status, nutritious foods are first channelled to men, then children, then women and inequity worsened at times of food insecurity (e.g. Harris-Fry et al. 2017, 2018).

Overall a number of factors influenced consumption of ASF in the participating rural villages in Timor-Leste. Factors with a positive influence included: participating in ceremonies, especially lengthy ones, where consuming ASF is part of the ritual; having available income to enable the purchase of ASF; having greater numbers of livestock, in particular smaller livestock such as chickens that are more likely to be slaughtered and consumed; living close to forests with wild animal populations; and women having greater control over resources and a greater role in household decision-making. Barriers to ASF consumption include low incomes or limited income streams, high levels of small livestock morbidity and mortality, leading to small flock or herd sizes, reserving livestock for sale and ceremonies, living far from forests or where hunting is not allowed. The benefits of ASF consumption particularly for undernourished women and children were evident, raising the question of how a sustainable system with improved availability, access and utilisation of ASF might be achieved. Raising household incomes together with development of policies and programs aimed at improving the health and production of small livestock species utilised by households, particularly those that are under the control of women, would be effective and sustainable in improving the nutritional status of households.

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Chapter 15
Wild Foods and Food Security: The Case of Timor-Leste

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Abstract Many rural households in the developing world are subject to chronic seasonal food insecurity. Foraging for wild foods is often cited among coping strategies. This study examined the role of wild food in household food security in Timor-Leste. Information on wild food use came from three sources: (a) a longitudinal study of food consumption among 14 subsistence farmer households across four districts in 2006–2007; (b) a survey in 2011 of 1,800 farmer households across all 13 districts in Timor-Leste; and (c) a survey of 64 households from eight community seed groups in three districts in 2013. The consumption of wild food fluctuated widely across the year with consumption much reduced in the wet season (December–April) compared to the dry season (May–November). Wild food use in a normal year, 2006–2007, and a food-deficit year, 2011, characterized by a severe hungry season, were compared. In the normal year, the maize grain store was exhausted in 50% of households (expressed as cumulative percentage of 'at-risk' households) during the month of August with 9.2% of households consuming wild food. By contrast in the food-deficit year, maize grain stores were typically exhausted two months earlier than in a normal year, and 50% of all interviewed households were foraging for wild food by May in four districts. In the food-deficit season, wild food foraging dramatically increased compared to a normal year, particularly by poor at-risk households. The early depletion of stored grain stocks under food insecurity resulted in greater coincidence of the period of wild food foraging with the hungry season than in a normal year. In two surveys, clear differences existed between districts in the extent of wild food foraging. The most

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widely eaten wild plant foods in Timor-Leste are lesser yam (*Dioscorea esculenta* considered wild in Timor-Leste) followed by elephant foot yam (*Amorphophallus paeoniifolius*) and bitter bean (*Phaseolus lunatus*). In the future in Timor-Leste, the wild food resource will continue to provide an important food buffer in deficit years especially to poor at-risk households, increasing their resilience and reducing their vulnerability.

Keywords Household food security · Wild food · Yams · Beans · Foraging · Timor-Leste

15.1 Introduction

Just three crops—wheat, maize and rice—contribute more than 50% of the world's daily requirement of proteins and calories (Harlan 1992; FAO 2013). However, many other species contribute immeasurably to the quality of life providing food, feed, fibre, medicines and ornaments. In the last 50 years, the trend has been towards increasing homogeneity in food supply based on a few globally important cereal and oil crops, which has led to a commensurate decline of other cereal, oil and starchy root species at the national level (Khoury et al. 2014). FAO recognizes that 'nutrition and biodiversity converge to a common path leading to food security and sustainable development' and that 'wild species and intraspecies biodiversity have key roles in global nutrition security' (FAO 2009). An important review of the use of wild foods concluded that wild food species form a significant portion of the total food basket for households from agricultural, hunter—gatherer and forager systems (Bharucha and Pretty 2012). Wild foods are often undervalued by agricultural and nutritional surveys, and the close links of agriculture with non-agricultural natural resources are underestimated (Asprilla-Perea and Díaz-Puente 2018; Carrasco et al. 2016). Pannell (2011) reported that the diverse nature of Fataluku economic practices in Timor-Leste—blending agricultural and hunter-gatherer-type activities—provided the kind of subsistence flexibility that enabled local people to deal with chronic environmental uncertainty. Clearly, resilient agrarian societies use swidden (shifting) farming and foraging activities to make a living. It is now well understood that humans do not just harvest wild food from an untouched pristine environment, but have been actively managing the environment over millennia (Bharucha and Pretty 2012). Such activities are undertaken by knowledgeable local societies and include selective culling of animals, irrigation management, planting, burning, habitat amendment and creation, nutrient additions and pest management.

Throughout the tropics, plants are transplanted from the wild, brought into the garden, and escaped again into the naturalized state where they are sometimes harvested. The movement of useful plants from wild conditions to the cultivated and back again is a relatively simple and common occurrence (Harlan 1992). In both agricultural and hunter-gatherer systems, a separation between 'wild' and 'cultivated' foods is not seen (Bharucha and Pretty 2012). Plant foods can thus be envisioned as 'existing along a continuum ranging from the entirely wild to the semi-domesticated, or from no noticeable human intervention to selective harvesting, transplanting and propagation by seed and graft' (Harris 1989). Moreover, since 'domestication grew out of food gathering, which almost imperceptibly led to cultivation', many wild edible species can be considered to be 'in various stages of domestication as a result of human selection, however slight' (Heywood 1999).

Timor-Leste has a food security problem: its population of 1.1 million has ranked third in a UN world ranking of countries with the highest percentage of chronically malnourished children since independence (UNICEF 2011). The overall nutrition situation of the country remains poor with 50% stunting, 11% wasting and 38% underweight in children under 5 years of age, undernutrition among mothers and micronutrient deficiencies among children and mothers especially resulting in anaemia (SEAMEO 2014). Most farm families suffer from food insecurity (WFP 2006) producing insufficient cereal staples of maize and/or rice to last a full year. Additionally, the recent national nutritional strategy emphasizes dietary diversity by increasing the availability of food from animal sources at household level and reducing micronutrient deficiencies (MOH 2014). Coping strategies for periods of food insecurity—the hungry season—includes the widespread use of tuber crops and extensive foraging for wild foods (da Costa et al. 2013). The habitat for wild foods is degraded forest, and its margins, and grasslands. In Timor-Leste, a profound change in the management of the forest resource occurred in the Indonesian period (1975–1999). In the period 1989–1999, there was a 14.6% reduction of woodland to degraded forest primarily through deforestation by corporate logging (Bouma and Kobryn 2004). Transmigration, government resettlement and local use also affected the vegetation resource base at this time. Part of the rural population was pushed to survive on wild food and medicines for extended periods as described in Pannell (2011). This radically reduced the active management of the forest resource—normally undertaken by repeated cutting, burning, cultivation and grazing. A revival in forest resource management and its close integration with the agricultural system has occurred since independence (Pannell 2011). Information on wild food harvested from this resource and its margins is scarce and fragmented.

This chapter summarizes and integrates information gathered by the Seeds of Life (SOL) program in Timor-Leste since 2006 on wild food to understand its role in food security. The focus of the study is on the use of non-tree wild plants for food plus sago palms harvested for their starch (excluding medicines and other uses), and the role of such plants in food security.

15.2 Information, Methodology and the Study Area

The study used three main data sources. The first was a longitudinal study of food consumption in 2006–2007 among 14 subsistence farmer households, each participants in Seeds of Life (SOL) on-farm trials in Aileu, Baucau, Liquiça and Manufahi districts (SOL 2007) (Fig. 15.1). These farmers' sole cash income was derived from the occasional sale of surplus produce (mainly chickens, pigs, palm wine and

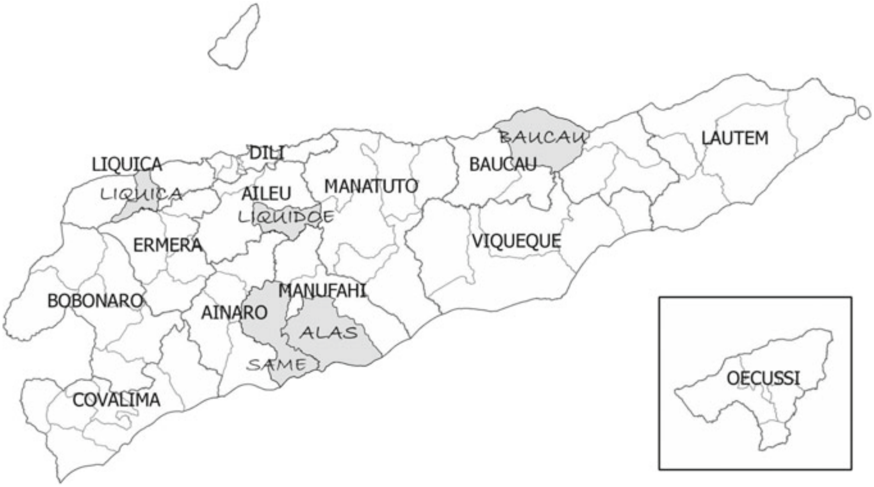

Fig. 15.1 Map of Timor-Leste showing districts and relevant sub-districts. Sub-districts in the 2006–2007 longitudinal study are named and shown as shaded areas

sweet potato in the dry season, and cassava and leafy greens in the wet). In the four districts surveyed (Aileu, Baucau, Liquiça and Manufahi), the main wet season is from December to April and the peak of the dry season is from May to November (Fig. 15.2). The length of the dry season varies from around 3–6 months according to elevation (upland or coastal lowland), and north or south coastal location. The peak of the hungry season is generally from November to February spanning the end of the dry season and the start of the wet season (da Costa et al. 2013).

The four districts vary. Upland Liquidoe (Aileu) typically has single-species dry forest (particularly *Eucalyptus urophylla* ST Blake) growing on steep hillsides on low-nutrient soils. Aileu has 83% forested land, 17% settled agricultural land and 0.3% grasslands (Glazebrook et al. 2007). It produces no rice or second season harvest and experiences regular severe wind damage to maize crops—suggesting a food-deficit area. The coastal hinterland around Baucau comprises an extensive plateau area with sparsely wooded eucalyptus forests and savannah grasslands. Baucau has 72% forested land, 16% settled agricultural land and 11% grasslands. Situated west of Dili on the north coast, Liquiça district is prone to an extended dry season along the coast and into the hinterland. The district's chronic food-deficit area with highly variable maize and other rainfed food crop production necessitates wild food foraging strategies. This is the only location where small game (monkey, cockatoo, bush fowl, turtledove, possum and reptiles) were recorded as being hunted. Liquiça has 64% forested land, 36% settled agricultural land and 0.1% grasslands. Finally, in the Alas sub-district in Manufahi district, forests include 27% cover of moist, dense lowland forest and nearly 10% moist mixed highland forest, where large game such as deer, pig and buffalo are hunted (SOL 2007). Manufai has 47% forested land, 45% settled agricultural land and 1% grasslands.

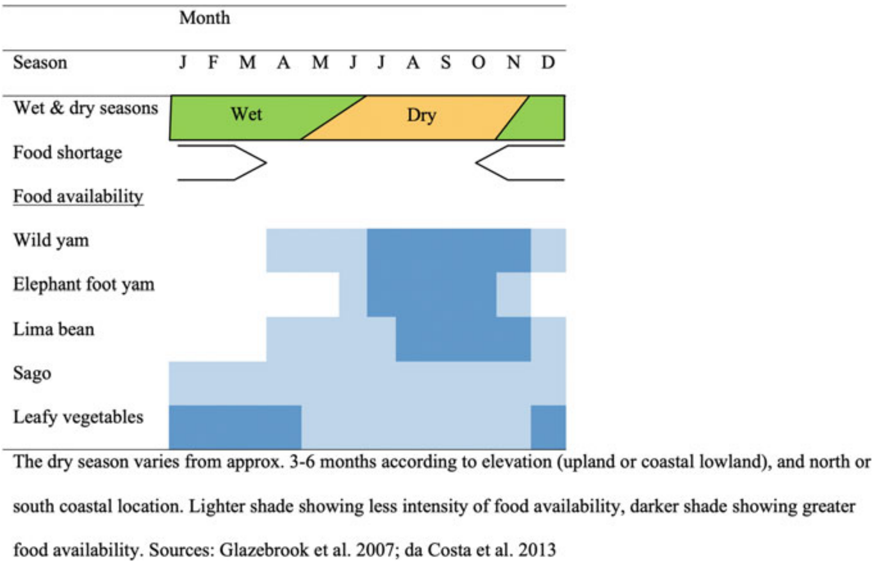

Fig. 15.2 Seasonal calendar showing generalized dry, wet and hungry seasons and the availability of key wild foods across the study area in Timor-Leste

For the 2006–2007 longitudinal study of food consumption (Glazebrook et al. 2007), visits were made every 4–6 weeks to monitor food consumption, wild food foraging and food access strategies across the dry and wet seasons. Based on a total of 119 interviews during the period April 2006–March 2007, the data provide a baseline of subsistence households' consumption practices and their strategies for securing food access prior to the impact of higher yielding staple food varieties evaluated by SOL. The interviewers specifically invited the wife of the household head to be the interview respondent, but in practice both were present and responded to questions during most interviews. The 14 farmers were randomly selected among the 340 on-farm maize trial farmers of that year so that they represented a range of biophysical and topographic conditions in each district. An open-ended questionnaire was used to inquire about food consumption. In order to elicit an extensive list of local food types, respondents were requested in the first interview to list, among others, wild foods usually consumed. In every subsequent interview, respondents were asked what food was eaten at every meal in the previous day, and these food types were taken to be representative of the month in which the interview was conducted. The respondents were also asked on the consumption of wild foods since the previous visit. Apart from these monthly visits, all households were also asked about processing, preparation and seasonality for all wild foods mentioned during the research. 'At-risk' households were defined as those with insufficient maize for the year (da Costa et al. 2013).

The second source is the SOL baseline survey conducted in October 2011 in 100 *sucos* (villages) randomly sampled from all 13 districts in Timor-Leste (SOL 2012b). A total of 1,800 households were interviewed on a wide range of subjects (SOL

2012b). The calculation of the sample was done proportional to the number of rural households in each district. The choice of the households to be interviewed followed a step-wise random selection approach to *sucos* (villages), *aldeias* (hamlets) and households within the *aldeia*. The interviews were conducted with an adult member of the household, but—as was often the case—other household members were present as well, and commented or were consulted on some of the answers. In the part of the interview on household food self-sufficiency, the respondents were specifically asked if in the previous 12 months they had consumed what they considered wild foods. If the answer was yes, the respondent was asked when this occurred.

The third source is a survey conducted with 64 households, belonging to eight community seed groups—a pre-existing farmer group that is supported by SOL to improve seed multiplication and distribution of new high yielding varieties of staple crops in isolated rural areas as part of the national seed system—in three districts: Ermera, Manatuto and Lautem (Fig. 15.1). Adult members of these households were interviewed as respondents to a questionnaire survey in April–May 2013, and asked how frequently they had to rely on gathering wild food as a coping strategy during months when they did not have enough food, and, more specifically, during which months in the previous year they had gathered free wild foods, and which ones.

From these surveys to understand how food security related to the use of wild food plants, we asked the following research questions: How does wild food consumption vary over the year in species composition and spatially by district? What plant parts are consumed and at which meal, and how are they prepared for consumption? Does wild food foraging increase as a response to food insecurity?

15.3 Results

In Timor-Leste, the extent of wild food foraging in any year depends on a combination of factors: yield of the previous crop harvest (supply) in relation to household needs (demand), the season in which foraging is carried out (most tubers are seasonal and harvested mainly in the dry season, while leafy greens are foraged in the wet season), and the type of vegetation/forest cover supporting the growth of food bearing plants.

The four districts surveyed in the 2006–2007 longitudinal study (Aileu, Baucau, Liquiça and Manufahi) were varied widely in ‘wild food’ carrying capacity. The number of wild food species (52) foraged in Liquiça sub-district, particularly leaves and small game, was double that of any other sub-district surveyed. This sub-district is the only location where small game were recorded as being hunted. By contrast, among the four districts, the least foraging of wild food occurred in coastal lowland Baucau (8 species) and upland Aileu, sub-district Liquidoe (11 species). A mixed forest (open woodland or savannah) which is moist but does not have a dense canopy supports a wide variety of wild foods, whereas denser forest combined with low population density supports habitat for larger game. This is evident for Alas sub-district in Manufahi district, where large game such as deer, pig and buffalo are hunted in forests that include 27% cover of moist, dense lowland forest and nearly

10% moist mixed highland forest. Foraging of roots and tubers was most prevalent in same sub-district, Manufahi.

15.3.1 Consumption of Wild Foods by District and Month

In the baseline survey, out of a total of 1,799 households that were surveyed across 13 districts, 1,543 (86%) reported that they had consumed wild foods during the previous 12 months. Figure 15.3 shows the percentage of households who consumed wild foods each month in the period from October 2010 to September 2011, first over the entire country and second in two extreme districts. Ermera district represents the highest consumption of wild foods. In contrast, Oecussi district—representing low consumption—was the district with the lowest percentage (36%) of respondents eating wild food. For all districts other than Oecussi, the percentage of households that consumed wild foods during the year varied from 67 to 99%.

The consumption of wild food fluctuated widely across the year with consumption much reduced in the wet season compared to the dry season, with the peak wild food consuming months from August to October in a normal season (2013) (Fig. 15.4).

15.3.2 Wild Food Foraging in Response to Food Insecurity

We tested the hypothesis that foraging for wild food is greater than normal during a period of food deficit by comparing wild food usage in a normal year (using data from the longitudinal study of food consumption in 2006–2007 in the four

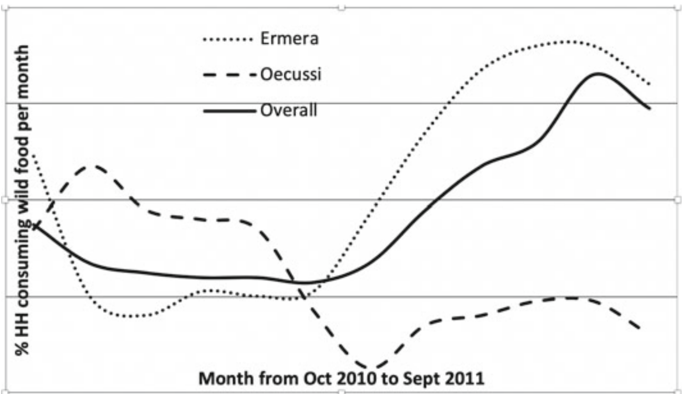

Fig. 15.3 Percentage of households (n = 1,543) consuming wild food in a month overall and in two extreme districts (Ermera high consumption n = 232; Oecussi low consumption n = 58) in 2011—a food-deficit year (SOL 2012b)

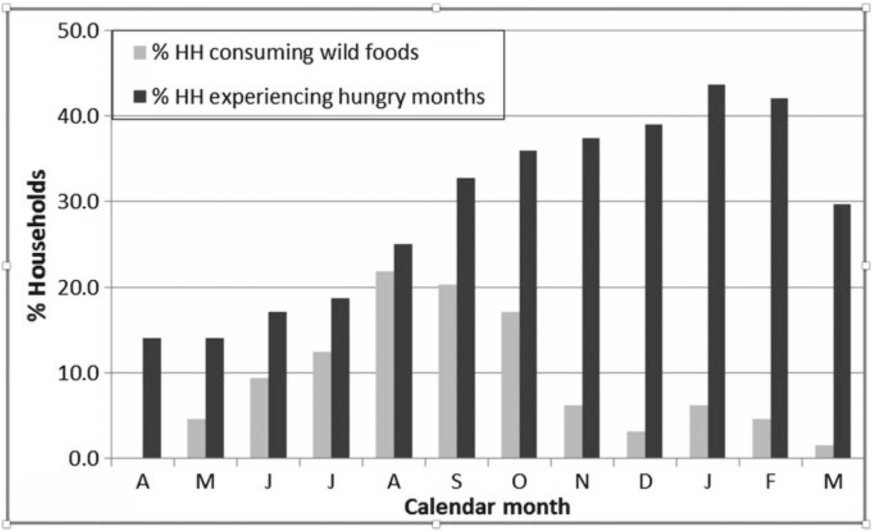

Fig. 15.4 Percentage of household respondents (n = 64) reported to experience hungry months and consume wild foods by month in the period April 2012–March 2013 in three districts (Ermera, Manatuto and Lautem)

districts of Aileu, Baucau, Liquiça and Manufahi districts) with a food insecure season 2010–2011 (data from the same districts extracted from the baseline survey conducted in October 2011). The onset of the hungry season occurs when 50% of 'at-risk' households (those with inadequate maize grain for the year) run out of stored grain (Fig. 15.5). Especially under food insecurity (2011) 50% of 'at-risk' households in all districts had clearly run out of grain by May and were forced to forage for wild food, 2 months earlier than usual. The contrast between 2011 and 2007 is stark and statistically significant ($P < 0.05$) in the four districts: in 2011 the percentage of households who foraged for wild food was 48% in July/August (Fig. 15.6), whereas only 9% of households consumed wild food in a normal year (2006–2007) in the same period. Clearly, in a food insecure season wild food foraging was dramatically higher than in a normal food secure year.

15.3.3 Types of Wild Food and Their Consumption by Season

We next consider what specific wild foods were consumed. In the 2006–2007 survey, respondents listed 33 species of wild food harvested at various times during the year. The most common were wild lesser yam *Dioscorea esculenta* (Lour.) Burkill (in the local language Tetun: *kumbili*), elephant foot yam (*A. paeoniifolius* L.) (Tetun: *Maek*), bitter bean (*Phaseolus lunatus* L.) (Tetun: *koto moruk*) and also sago starch.

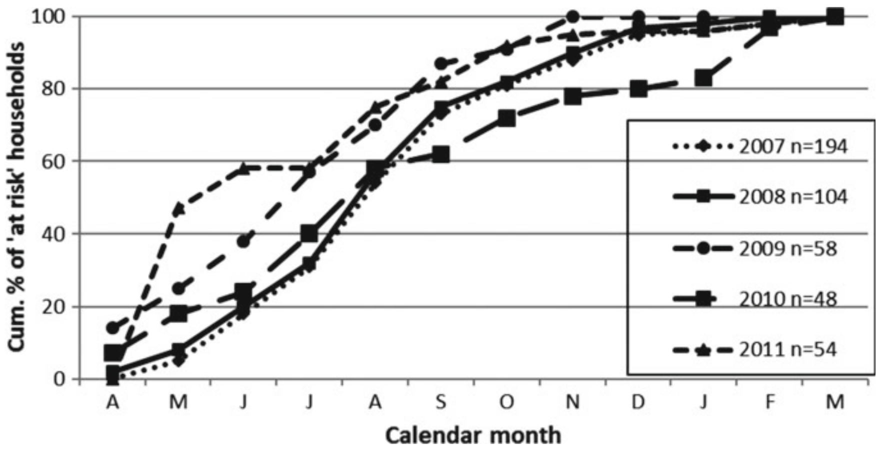

Fig. 15.5 Month when grain store is exhausted expressed as cumulative percentage of 'at-risk' households (those with insufficient maize stored to last the year). *Sources* SoL (2008, 2009, 2010, 2011, 2012a)

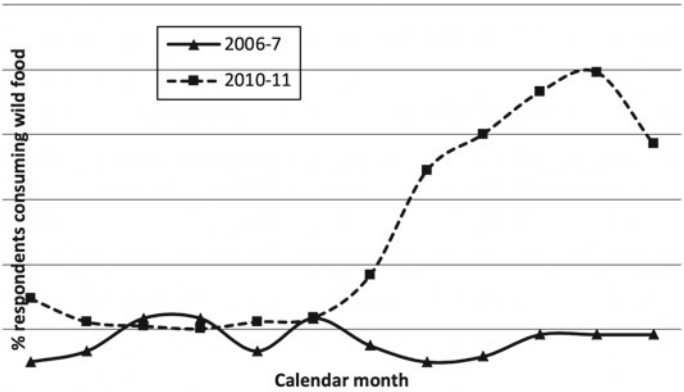

Fig. 15.6 Percentage of household respondents consuming wild food in a month in an average season for maize production (2006–2007; n = 119) and a very low maize production season (2010–2011; n = 473) in four common districts (Aileu, Baucau, Liquiça and Manufahi). Data extracted from SoL (2007, 2012b)

The yams consumed in Timor-Leste also include *D. alata* L. (Tetun: *uhi)*, *D. hispida* Dennst. (Tetun: *kuân)* and rarely *D. pentaphylla* L. and *D. bulbifera* L.

Sago consumption is confined to coastal areas of Timor-Leste, suggesting little marketing to upland areas. The data do not distinguish between the two trees described as *akar* in Tetun and commonly translated as sago: these are 'true' sago (*Metroxylon sagu* Rottb.) and 'false' sago which is the sugar palm (*Arenga pinnata* (Wurmb.) Merr.). Edible starch is harvested from the trunks of both palms in the same way. Sago may be sold as processed starch, and also, as debarked blocks where the pith is intact. Elsewhere in Southeast Asia, sugar palms which have not responded to tapping are considered to yield the highest quantity of starch. However, starch recovered from the pith of the trunk is secondary to tapping the palm‘s flowers for juice from which palm sugar is obtained, and palm wine (Tetun: *tuak*) is fermented and distilled. The annual farmer survey showed little use of sago, which in the coastal areas is a food of last resort or a famine food for humans. It is fed more regularly to pigs. The lack of respondents eating sago showed there was other food available at the time. Other significant wild foods consumed include tree cassava (*Manihot glaziovii* Müll. Arg.) (Tetun: *buraisa*), tubers of the yams *Dioscorea alata* and *D. hispida*, (each 3%; N = 4 from 119 respondents) and *Aisame* tuber (*Puereria sp.*), wild taro (*Colocasia esculenta* (L.) Schott.), tamarind (*Tamarindus indica* L.) and velvet bean (*Mucuna pruriens* (L.) DC) (each 1%; N = 2).

Over the seasons, the consumption of specific wild foods varies (Table 15.1; Fig. 15.1) and Table 15.2 shows the most commonly consumed wild food types by season in the 2006–2007 longitudinal study. The diversity of available wild foods is far more extensive in the dry season than the wet season. No foraging was carried out during the period January–February, but significant foraging was done in November and December. *D. esculenta*, *P. lunatus* and sago were the most commonly foraged foods across both seasons, but significantly less so in the wet season. Wild tubers such as *D. esculenta and D. alata*, and *A. paeoniifolius* were mainly foraged in the dry season. Sago consumption was highest during the period of food shortage. Bitter tree cassava was reportedly consumed during the food shortage period only, reflecting its use as a reserve food.

15.3.4 Parts Used, Their Preparation and Consumption

The 2006–2007 study revealed that several parts of wild foods are used: for example, flesh of the tuber, seed, flower, fruit and leaves. The parts of wild foods used and the preparation required are detailed in Table 15.2. Wild tubers and *A. paeoniifolius* are pounded (Tetun: *fai*) to become powder (Tetun: *uut*), which is then boiled once or twice before eating. The leaves of some tubers (for example, wild taro *Colocasia esculenta*) do not require specific preparation and are also cooked with maize. Most wild leaves picked from bushes or trees are selected for tenderness and, after boiling with maize in the same cooking pot, are eaten together. Leaves from *A. paeoniifolius* and leaves from bitter tree cassava are the exception and must be boiled and squeezed prior to cooking. Beans (bitter lima bean—*P. lunatus*, *Mucuna* bean (*Mucuna pruriens* (L.) DC, and *kalik* bean (*Entada phaseoloides* (L.) Merr.) are all boiled repeatedly, up to 10 times. One respondent in Baucau prepared tamarind by removing the flesh, which was subsequently sold as a vegetable, and boiling the seed five times to remove bitterness before eating.

Tubers, roots and cereals are the main foods consumed for breakfast (Tetun: *matabisu* or *han dader*). Cassava is by far the most common breakfast food across the year (Table 15.3). Cereals and tubers are the main foods consumed for lunch (Tetun: *han meu dia*), usually accompanied by leafy greens, beans or pawpaw flowers/leaves.

Table 15.1 Most commonly consumed wild foods (percentage of respondents) by season of study period in 2006–2007 (SOL 2007)

Season	1 (most commonly consumed)	2	3	4	5
Dry (May–November) N = 60	*D. esculenta* 45% (N = 27)	*P. lunatus* 18% (N = 11)	*Metroxylon sagu/Arenga pinnata* 13% (N = 8)	*A. paeoniifolius* and *D. alata* 6% (N = 4)	*D. hispida*, *Puereria* sp. and *M. pruriens* 3% (N = 2)
Wet (December–April) N = 59	*D. esculenta* 8% (N = 5)	*P. lunatus* 8% (N = 5)	*Metroxylon sagu/Arenga pinnata* 6% (N = 4)	*M. glaziovii* 5% (N = 3)	*D. hispida* 3% (N = 2)
Food shortage period (November–February) N = 44	*D. esculenta* 20% (N = 9)	*Metroxylon sagu/Arenga pinnata* 15% (N = 7)	*P. lunatus* 9% (N = 4)	*D. hispida* 6% (N = 3)	*C. esculenta* and *M. glaziovii* 6% (N = 3)

Table 15.2 Wild foods, parts used and preparation as reported by study respondents in longitudinal household consumption study 2006–2007

Botanical name	Part eaten	Preparation required	Problems with food use	Season harvested
D. esculenta	Flesh of tuber	Roast or boil	None	Dry
P. lunatus	Leaves	Boil leaves with maize kernels (some squeeze in cold water twice prior to cooking with maize)		Dry
	Beans	Boil beans up to 10 times, discarding water after each boiling, then eat	Poisonous if not boiled	
A. paeoniifolius	Leaves	Boil leaves 1–2 h before cooking with maize Kernels	Can produce itchiness if not boiled properly	Dry
	Flesh of tuber	Flesh can be dried, pounded into meal and finally steamed (peel tuber, cut into pieces and dry, then pound to become meal, soak in hot water, pound again then steam for eating) or soaked, dried and finally boiled (peel tuber then slice then boil, then soak for 5–6 days then dry, then boil for eating together with maize or mix with green vegetables)		
M. glaziovii	Leaves	Boil leaves and squeeze twice prior to cooking for eating	Poisonous if not boiled properly	Dry and wet
	Flesh of tuber	Soak tuber flesh in water for 2 days then boil		
D. hispida	Flesh of tuber	Bake until cooked then scrape away the downy surface before eating	None	Dry
M. pruriens	Bean	Boil beans up to 10 times, discarding water each time	Poisonous if not prepared	Dry

(continued)

Table 15.2 (continued)

Botanical name	Part eaten	Preparation required	Problems with food use	Season harvested
D. alata	Flesh of tuber	Flesh Boil or roast	None	Dry
Pueraria sp.	Leaves	Leaf tips are boiled together with maize	None	Dry
	Flesh of tuber	Tuber can be soaked in water for 3 days and nights then boiled for eating		
E. phaseoloides	Bean	Roast and remove shells then boil and cut then mix with bitter bean and boil together 7–8 times and finally soak in cold water before eating	Poisonous if not prepared	Dry
C. esculenta	Leaves	Boil leaves together with maize	None	Dry
	Flesh	Boil tuber with skin for 1 night then skin and eat		
Moringa oleifera (L.) Vahl	Leaves, Fruit, Flower	Boil leaves, fruit and flowers with maize to make porridge/sasoro	None	Dry and wet
Tamarindus indica	Flesh, seed	Seeds must be boiled five times before eating	Bitter	Dry

Consumption of rice is almost twice as common in the dry season compared to the wet, and least likely to be consumed in February until May when maize replaces rice as the main food. Like lunch, the evening meal (Tetun: *han kalan*) consists of cereals and tubers accompanied by leafy greens, beans, pawpaw leaves/flowers or other vegetables. Rice is the most common food eaten for the evening meal in both seasons but frequency of consumption decreased dramatically during the end of the wet season (February–May). In the dry season, rice is almost three times more likely to be consumed than maize, whereas in the wet season, rice and maize are equally likely to be eaten. Sweet potato and *D. esculenta*, both harvested in the dry season, form part of the evening meal during this period, and are not consumed at all in the wet season.

Table 15.3 The percentage of respondent households (HH) (n = 119) that consumed each of the various types of food at breakfast, lunch and evening meals during the 12-month period of 2006–2007 in four districts (Aileu, Baucau, Liquiça and Manufahi). Wild foraged foods are emboldened

Breakfast	Lunch	Evening meal
Manihot esculenta (44%)	*Zea mays* (42%)	*Oryza sativa* (50%)
Zea mays (14%)	*Oryza sativa* (39%)	*Zea mays* (30%)
Oryza sativa (13%)	*Manihot esculenta* (27%)	Leafy greens[a] (24%)
Musa spp. (9%)	Leafy greens[a] (18%)	*Manihot esculenta* (21%)
Bread/Wheat Flour (8%)	*Carica papaya* (15%)	*Carica papaya* (13%)
Ipomea batatas (6%)	*Vigna unguiculata* subsp. *sesquipedalis* beans (119%)	*Cucurbita* spp. (9%)
M. sagu/A. pinnata (5%)	*Cucurbita* spp. (8%)	*Vigna unguiculata* subsp. *sesquipedalis* (7%)
Colocasia esculenta and ***D. esculenta*** (each 4%)	*Phaseolus vulgaris* (5%)	*Ipomea batatas* (3%)
Mangifera indica, and *Maranta arundinacea* (each 3%)	*Ipomea batatas* (4%)	*Musa* spp. (3%)
P. lunatus, *Cucurbita* spp. and ***M. oleifera*** (each 2%)	***D. esculenta,*** and ***M. sagu/A. pinnata*** (each 3%)	*Phaseolus vulgaris* (3%)
	P. lunatus and *Mangifera indica* (each 2%)	*Artocarpus altilis*, ***D. esculenta***, ***M. sagu/A. pinnata*** and *Solanum melongena* (each 2%)
	Artocarpus altilis, Noodles, *Glycine max*, *Vigna radiata*, *Musa* spp., *Maranta arundinacea* & *Cocos nucifera* (each 1%)	***P. lunatus***, *Mangifera indica*, *Vigna radiata* and *Glycine max* (each 1%)

[a]Leafy greens undifferentiated—Most commonly consumed greens are listed in Table 15.2

15.4 Discussion

Foraging for wild food is often observed as a response to household need and as an indicator of food insecurity (Bharucha and Pretty 2012; Cruz-Garcia and Price 2014; Sthapit et al. 2008). In 2006, national maize production was 118,984 t, which is close to the annual average production from 2006 to 2012 of 108,708 t (FAO 2013). By contrast, in the season 2010–2011 maize production in Timor-Leste was particularly poor at 30,666 t (28% of the long-term average). Consequently, the following hungry season (2011) was particularly severe. We found that in this food-deficit year (2011) wild food foraging increased and indeed plays a substantially larger role in the diet compared to a normal season (2006–2007) in all four districts. Households pushed to wild food foraging are those whose maize stocks are exhausted, and were previously identified as the most ‘at-risk’ from food security (da Costa et al. 2013). Wild food use within the rural population is thus of greatest importance to poor ‘at-risk’ households, confirming the recognition that poor households depend most on wild foods (Bharucha and Pretty 2012; de Merode et al. 2004). Despite the link between wild food foraging and poverty, there was no obvious reluctance or stigma associated with foraging for food. That wild food is perceived as complementary to cultivated food within the diet is shown by the diverse dietary components of meals.

In a normal season, from the food security viewpoint, the hungry season starts as maize grain stores begin to empty in July/August and peaks from November to February (da Costa et al. 2013). In such years, the peak for wild food foraging was from August to October, confirmed in SoL (2016), which overlaps with but does not entirely coincide with the timing of the hungry season. By contrast, however, in a food insecure year, there was greater coincidence of wild food foraging with the hungry season which starts early and is therefore extended. Foraging for wild food is one of several coping strategies for the hungry months. Such strategies include the use of crop diversification with tubers playing a lead role as grain stocks dwindle, selling animals and other assets, and using social networks for support (da Costa et al. 2013; Browne et al. 2017). Additionally, tubers such as sweet potato, cassava and wild yam are dried for storage and consumption in the wet season (Glazebrook et al. 2007).

Considerable variation existed between districts in wild food use, related to the diversity in vegetation. The longitudinal survey (2006–2007) picked up differences among the four districts in their wild food carrying capacity. Liquiça sub-district had the highest diversity in wild foods. The district’s chronic food-deficit area with highly variable maize and other rainfed food crop production necessitates wild food foraging strategies. By contrast, the least foraging of wild food occurred in coastal lowland Baucau and upland Aileu, sub-district Liquidoe. In the case of Baucau, this was probably due to the capacity for surplus agricultural production, where there is access to river or streams for irrigation allowing second season planting of commodities such as rice, maize, sweet potato and cassava. Moreover, the coastal area around Baucau with sparsely wooded eucalyptus forests and savannah grasslands does not support extensive wild food. Upland Liquidoe produces no rice or second season harvest and is a food-deficit area. Overall, mixed forest (open woodland or savannah) which is moist but without a dense canopy supported a wide variety of wild foods, while a denser forest provided habitat for larger game.

The most widely consumed wild foods in Timor-Leste are lesser yam (*D. esculenta* considered wild in the context of Timor-Leste) followed by the two wild species: elephant foot yam (*A. paeoniifolius*) and bitter bean (*P. lunatus*). All three species are known as crop plants (Purseglove 1968, 1972). Among the three species, *D. esculenta* is probably native to mainland Southeast Asia and it is not widely grown outside Asia and the Pacific (Purseglove 1972). It grows wild in parts of South and Southeast Asia, but it is not known whether these are escapees from ancient cultivation or real relicts of its natural distribution area (Onwueme 1996). Evidence of *D. esculenta* in the archaeological record remains elusive. In Timor-Leste about 90% of *D. esculenta* is foraged from outside gardens, or may be transplanted into a garden and cultivated for its edible and starch-rich underground tuber (Glazebrook et al. 2007). Metzner (1977) also noted that *D. esculenta* is planted in house gardens together with other root crops, maize and beans. The second species, elephant foot yam (*A. paeoniifolius*), grows wild in Southeast Asia and the Pacific (Purseglove 1972). Because it easily escapes cultivation and naturalizes, its exact origin is unknown (Jansen et al. 1996). By contrast to the other species, lima bean (*P. lunatus)* has a New World origin and domestication (Salgado et al. 1995; Andueza-Noh et al. 2013). Post-Columbus the Spanish carried the lima bean to the Philippines, whence it spread to other parts of Asia (Purseglove 1968). Lima beans have escaped from cultivation and become naturalized in many tropical countries (Purseglove 1968), including Timor-Leste.

Wild food is highly time and energy consuming, to forage and to prepare, compared to domesticated crop produce. The process of repeated boiling to remove bitterness or toxins is common practice in preparation of wild foods, mainly beans, and a specific term in the Tetun language (*tisi*) describes this practice. Tubers and beans are the most commonly consumed wild foods, and require labour-intensive processing prior to cooking, in addition to carrying firewood and water to remove toxic components, such as the glucoside phaseolutanin which denatures to hydrocyanic acid in lima beans (Purseglove 1968), L-dopa in *Mucuna* bean (Correia et al. 2014) and calcium oxalate in elephant foot yam (Purseglove 1972).

Looking ahead to 2050 steady increases in temperature and rainfall are anticipated in Timor-Leste but these can be accommodated through breeding and management. However, the increasing frequency of extreme temperatures and intensity of cyclones (with high wind speeds) and extreme rainfall events (such as 2010–2011) are likely to cause greater challenges for farmers (Molyneux et al. 2012). Thus, the markedly low maize production in Timor-Leste in 2010–2011 was because of an extremely wet growing season in which farmers were unable to clear and burn land at planting time. This extreme weather event was part of the La Niňa phase of the El Niňo Southern Oscillation (ENSO) cycle which strongly affected Timor-Leste (Fox 2003). Overexploitation of the wild food resource base by excessive harvesting, following a series of such food insecure seasons, will have major effects on the sustainability of the system. However, a larger threat to bitter beans and the wild lesser yam, which grow in grasslands, is the invasion of weeds especially Siam weed (*Chromolena odorata* (L.) King & Robinson) (McFadyen 2003). By contrast, elephant foot yam is often on the forest edge. The extent of the forest margin habitat depends on the continuation of swidden agriculture and logging. Both may be anticipated to increase in the future so there is unlikely to be any habitat loss. Elsewhere in Southeast Asia biodiversity in swidden fallows has traditionally provided communities with ways to increase income and improve diets, with most wild food coming from fallows rather than mature forests. With the replacement of swidden farming by annual or perennial crops (Bruun et al. 2009), wild foods that accompanied fallows are being lost, leading to decreased diversity, and thus downgraded nutritional status, health and income, and the removal of a 'safety net' for the rural poor (Rerkasem et al. 2009). In Timor-Leste, the wild food resource and close integration of non-agricultural systems with agricultural systems will continue to provide an important food buffer in food-deficit years.

15.5 Conclusions

This study examined the role of wild food in household food security in Timor-Leste. The consumption of wild food fluctuated widely across the year with consumption much reduced in the wet season (December–April) compared to the dry season (May–November). Wild food use in a normal food security year (2006–2007) differed markedly from a food-deficit year (2011), characterized by a severe hungry season. In the normal year, the percentage of households consuming wild food was 9%, and the maize grain store was exhausted in half of the households during August. In marked contrast, however, in the food-deficit year, the maize grain store was exhausted 2 months earlier than in a normal year and half of the households were foraging for wild food by June. The early depletion of stored grain stocks under food insecurity resulted in the greater coincidence of the period of wild food foraging with the hungry season than in a normal year. In Timor-Leste, wild food use is of greatest importance to poor 'at-risk' households within the rural population, but with clear differences between districts in the extent of wild food foraging. The most widely consumed wild foods in Timor-Leste are lesser yam (*D. esculenta*), elephant foot yam (*A. paeoniifolius*) and bitter bean (*P. lunatus*). Wild food resources will continue to provide an important food buffer in food-deficit years, especially to poor at-risk households, increasing their resilience and reducing their vulnerability.

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