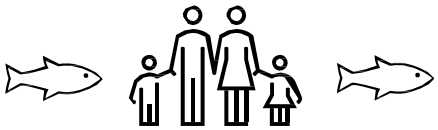
Understanding the Social Dimensions of Small-Scale Tilapia Aquaculture in Rural Solomon Islands



Thesis submitted by:
Daykin Otowauri Harohau
BSc Marine Science (University of the South Pacific)

For the Degree of Doctor of Philosophy in Physical & Natural Sciences

Division of Tropical Environments & Societies
College of Science and Engineering, James Cook University
Queensland, Australia

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List of Acronyms

ACIAR	Australian Centre for International Agricultural Research
ADRA	Adventist Development Relief Agency
ASF	Animal – sourced food
DOI	Diffusion of Innovation
MFMR	Ministry of Fisheries and Marine Resources
MSL	Material styles of life
PICT	Pacific Island Countries and Territories
SDGs	Sustainable Development Goals
SLF	Sustainable Livelihood Framework
SPC	Pacific Community
SSA	Small-scale aquaculture

Acknowledgement

If it were for my own strength, knowledge and understanding, I would not have come this far. To God (The Lion of the Tribe of Judah) be all honour for enabling me to complete this PhD. It was not an easy journey from start to finish. Despite an academic journey, it was also a personal and spiritual one for me as I have encountered both challenges and countless blessings along the way. I am indeed indebted to many people who have helped me through my candidature.

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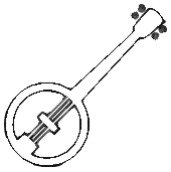
Dedication

This PhD is dedicated in honour of my late father, Benjamin Harohau whom the Lord called to rest on the 25th of December 2019. My father was my biggest supporter, who afforded me the opportunity to have a good education. The one who taught me many valuable lessons in life – that hard work, perseverance and commitment are prerequisites to achieving greater things in life.



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Thesis abstract

In many developing countries, there are few opportunities for people to improve their livelihoods and address their food security needs. The introduction of small-scale aquaculture (SSA) has been identified as one of a multiple of livelihood activities that may increase opportunities for improving livelihood outcomes and addressing food insecurity for people living in rural areas. Nonetheless, SSA's potential to translate into a tangible livelihood is contingent upon several factors which, among others, include the aquaculture commodity farmed. In Asia and Africa where most studies have been conducted, empirical evidence remains inconclusive on whether SSA has led to improved livelihoods and food security of the poorest farmers.

This study explores SSA from a Pacific Islands context looking at small-scale tilapia aquaculture in rural Solomon Islands. Specifically, the dissertation addresses four research questions: 1) which social factors influence the adoption of small-scale tilapia aquaculture in rural Solomon Islands? 2) what contribution has small-scale tilapia aquaculture made to rural livelihoods to date? 3) what contribution has small-scale tilapia aquaculture made to household diets? and 4) what barriers and opportunities are institutions that are supporting small-scale tilapia aquaculture development in Solomon Islands facing in their efforts to develop the sector further?

Findings from this study revealed that socio-economic factors, such as age, subsistence level of households and material styles of life (MSL) influenced the adoption of small-scale tilapia aquaculture among rural farmers more than communication channels and attributes of the innovation. Small-scale tilapia aquaculture in its current form in Solomon Islands has contributed negligibly to the livelihood outcomes of people in rural areas. Small-scale tilapia aquaculture has also contributed minimally to the animal protein consumed by households. Marine fish remained important amid the diverse types of fish consumed, while processed fish products were the preferred alternative – possibly due to their cost effectiveness, accessibility, and sustained shelf life. Finally, institutions that supported the development of small-scale tilapia aquaculture in Solomon Islands stated that the poor performance of the current tilapia species (*Oreochromis mossambicus*) is an important limitation to the sector's tangible contribution to food security. Hence, while SSA initiatives such as tilapia aquaculture have been shown to contribute to improved livelihoods in other geographical contexts, in Solomon Islands, it is not making similar contributions.

This thesis, therefore, extends the global narrative on SSA and its impact on food security and livelihood opportunities beyond developing contexts of Asia and Africa to the Pacific Islands region. For the Pacific Islands regional context, this thesis provides a baseline understanding of the social dimensions that can determine whether people experience benefits (e.g., food and income) from small-scale tilapia aquaculture as a complementary fish production source to coastal fisheries.

Statement of contribution from others

Supervision

Dr Amy Diedrich and Dr Jessica Blythe supervised this thesis from its conceptualisation to completion. Dr Philippa Cohen also helped in conceptualising the thesis but was predominantly involved in the supervision of the data presented in the fourth chapter of this thesis. Dr Cohen also played a major part in critiquing the other chapters in this thesis. Professor Marcus Sheaves provided mentorship and constructive feedbacks to all chapters, particularly at the final drafts phase.

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Approval for research involving human subjects was granted for the data collection for this research project by the James Cook University Human Research Ethics Committee (Ethics Approval No.: H6870) on the 1st of March 2017. Because I also relied on some information sourced from WorldFish in Auki, Malaita Province, a consent letter was also provided by WorldFish before I conducted my fieldwork.

Outputs related to this thesis.

Peer-reviewed papers

Blythe, J., Sulu, R., **Harohau, D**., Weeks, R., Schwarz, A-M., Mills, D. and Phillips, M. (2017). Social Dynamics Shaping the Diffusion of Sustainable Aquaculture Innovations in the Solomon Islands. *Sustainability,* 9, 126; doi:10.3390/su9010126

Harohau, D., Blythe, J., Sheaves, M., & Diedrich, A. (2020b). Uneven adoption of tilapia aquaculture in rural Solomon Islands. *Aquaculture International*. 28, 2093-2109. https://doi.org/10.1007/s10499-020-00577-2

Harohau, D., Blythe, J., Sheaves, M., & Diedrich, A. (2020a). Limits of Tilapia Aquaculture for Rural Livelihoods in Solomon Islands. *Sustainability*, 12(11), 4592. https://doi.org/10.3390/su12114592

Papers prepared for submission.

Harohau, D., Cohen, J.P., Albert, J., Blythe, J., Wate, T.W., Sheaves, M., & Diedrich, A. (in preparation). Tilapia aquaculture: filling the animal-source food gap in a rural setting? *Aquaculture Research*.

Conference presentations

Harohau, D. (2017) "Fish from small-scale coastal fisheries, or tilapia pond aquaculture?" In: Cohen, P., Huchery, C., & Roscher, M. (eds.2017). *Resilient Small-scale Fisheries Symposium, Proceedings of a workshop held in Penang, Malaysia, 5–7 September 2017*. pp: 74. ACIAR Proceedings, No.: 147. Canberra: ACIAR.

1. Chapter 1: General Introduction

1.1. Background

Increasing human populations coupled with limited livelihood opportunities are contributing to increased food insecurity in many places around the world. As a result, an estimated two billion people (or 26.4% of the world's population) are currently without regular access to safe, nutritious, and sufficient food (FAO et al., 2020). Most (80%) of these poor and marginalised people live in rural areas and predominantly come from developing countries (Castañeda et al., 2018). More so, the high prevalence of food insecurity implies that efforts to achieve the United Nation's Sustainable Development Goal 2 – which aims to attain zero hunger by 2030 – has so far been inadequate (Nash et al., 2020; Obiero et al., 2019). This also means that considerable effort and work remains to be done, especially in developing countries by encouraging livelihood diversification for rural communities to adequately attain food security in their respective contexts (Pritchard et al., 2019).

1.2. Importance of fish in addressing global food and nutrition security.

In many developing countries where food security and undernourishment are widespread, fish is an important food source in household diets (FAO et al., 2020; Kawarazuka & Béné, 2011; Purcell & Pomeroy, 2015). It is estimated that over three billion people globally obtain 20% of their animal protein intake from fish (FAO et al., 2020). In fact, the latest Food and Agriculture Organisation (FAO) report on the status of global fisheries and aquaculture revealed that global fish consumption has increased at an annual average rate of 3.1% from 1961 to 2017; roughly twice the annual population growth rate of 1.6% in the same period (FAO et al., 2020). The increase in global fish consumption has been attributed to the increase in fish production from capture fisheries and aquaculture, but also the advancement in technology, the rising level of income giving rise to increased demand for fish, plus increased awareness of the health benefits of consuming fish (bid). In the small island developing states of the Pacific Islands where fish consumption is exceedingly high, it (fish) accounts for 50-90% of dietary animal protein in local diets, particularly in rural coastal communities (Bell et al., 2009; Charlton et al., 2016).

Fish is a source of high-quality animal protein, omega-3 polyunsaturated fatty acids, essential micronutrients (e.g., zinc, iodine, iron, vitamin D, etc.) and minerals. Nutrient composition, on the other hand, varies among species – whether farmed or non-farmed – and if they are

tropical or temperate fishes (Bogard et al., 2017a; Hicks et al., 2019; Kawarazuka & Béné, 2011; Mohanty et al., 2019; Roos et al., 2007). Protein derived from fish also facilitates faster absorption of plant-based proteins consumed, which in-turn boosts total protein intake sourced from both animal-sourced foods (ASFs), including fish, and plant-based food (Kawarazuka & Béné, 2011).

Fish also have unique polyunsaturated fatty acids (EPA 20:5n-3 and DHA 22:6n-3) that are essential for both child development and the overall health of adults (Calder & Yaqoob, 2009). In adults, healthy fatty acids can reduce the risks of breast, colon, and prostate cancers (Zárate et al., 2017). While micronutrients found in fish are also essential for metabolic body functions, they are also important for bone development (Hays & Roberts, 2003), oxygen transportation throughout the body (Abbaspour et al., 2014), the body's central nervous and immune systems, and skeletal and gastrointestinal organs (Roohani et al., 2013).

In addition to its various health benefits, fish also provides a cheap ASF which is frequently consumed by poor households, amid an otherwise monotonous diet of staple crops (Belton & Thilsted, 2014). Fish accounts for >50% of ASF consumed in many developing countries (FAO, 2020). For instance, in Bangladesh fish accounts for 60% of ASFs in local diets, second only to rice (Belton & Thilsted, 2014). Another study by Belton et al. (2014) in Bangladesh also revealed that 80% of households consumed fish in the previous three days, while only 20% consumed any form of meat in the same period. In Africa, it is estimated that 200 million people are consuming fish as their main ASF with fish accounting for 36% of animal protein consumed, where 21% is from marine fish, 11% from inland fisheries, and 5% from aquaculture (AUC-NEPAD, 2014). In the Pacific Islands region, the limited availability of arable land constrains the availability of diverse agricultural food crops for human consumption. Thus, there exists a strong tradition of per-capita fresh fish consumption in the region that exceeds the World Health Organisation's recommended animal protein intake of 34-37kg/person/year, especially in coastal communities (Bell et al., 2009; Farmery et al., 2020).

1.3. Increasing pressure on capture fisheries, and potential of aquaculture production

Globally, fish is supplied by both capture fisheries and aquaculture (FAO, 2020). In 2018, combined global fish production from the two sectors peaked at 178 million metric tonnes

valued at USD401 billion. Capture fisheries accounted for over half (54%) of this production. While most (87.6%) of global fish production is destined for human consumption, the remainder is diverted for other purposes, such as fish feed, agricultural fertilizer, and others (FAO, 2020). In terms of fish production by region, the greater portion of fish production from both sectors comes from Asia. People's Republic of China alone accounted for 35% of global fish production, 34% comes from wider Asia (China excluded), 14% from the Americas, 10% from Europe, 7% from Africa, and only one percent from the Pacific Islands region (FAO, 2020). Furthermore, it is evident that across developing countries where fish production is greatest, capture fisheries provide the bulk (90%) of fish destined for human consumption (Hall et al., 2013; Temesgen et al., 2019). This is because the majority of the poor and marginalised fisherfolks – who are subsistence fishers – are dominantly involved in this sector which forms an integral part of their livelihoods and food security (Allison et al., 2011; Béné et al., 2016; Dey et al., 2008; Scholtens & Bavinck, 2017).

In larger developing countries, capture fisheries occur in two distinct forms: inland and marine fisheries. In some Asian and African countries with significant waterbodies, for instance, Bangladesh, Myanmar, Cambodia, Uganda, and Nigeria, inland fisheries provide most of the fish for export and domestic consumption (Bartley et al., 2015; Belton et al., 2014; Funge-Smith & Bennett, 2019). In 2015, it was estimated that total inland fisheries production peaked at 11.47 million tonnes and accounted for 12.2% of total global capture fisheries production – although this data from national fishery statistics maybe scattered and underrepresented (Funge-Smith & Bennett, 2019). Of the 34 countries driving the development of the inland fishery sector, majority are developing countries from Asia and Africa, except the Russian Federation (ibid). On the other hand, in the Pacific Island region and some African countries (especially those of Western and Eastern Africa), marine fisheries make up the bulk of fish production (FAO, 2020). For instance, in many Pacific Island Countries and Territories (PICTs) fish from coastal fisheries make up >50% of all ASF consumed, and 90% of types of fish consumed (Bell et al., 2009; Charlton et al., 2016). In Africa, an estimated 411,000 metric tonnes of fish from subsistence coastal fisheries were utilised for domestic consumption in 2010 (Belhabib et al., 2019).

However, current evidence indicates that global capture fisheries production has plateaued since the early 1990s, and continues to do so today (FAO, 2020). In many developing countries where empirical evidence is available (e.g., Bangladesh), this has been the result of

an increasing population, rapid economic development (e.g., urban development leading to increased rural-urban drift, infrastructure construction, and agriculture intensification, etc.) exerting increased pressure on capture fisheries production (Belton et al., 2014). This stagnant capture fisheries production will inflict adverse impacts, especially on the poor in developing countries who are heavily reliant on the sector for their livelihood and food security needs. This is even more concerning given that global per capita fish consumption in developing countries has significantly increased in the last decades, from about 5.2kg per year in 1961 to 219.4kg in 2017 – an annual growth rate of 2.4%; an increase in fish consumption ascribed to factors like improved income levels, improved processing and distribution, reduction of loss and waste, and increased demand for fish, notably in most developing countries (FAO et al., 2020).

Aquaculture has been touted as the fish production sector that will provide the extra fish needed to supply the increasing demand for fish, especially across developing countries where fish is heavily relied upon for food (Belton & Thilsted, 2014; Tran et al., 2019). In 2018, almost half (46%) of the total global fish production was provided by aquaculture (114.5 million metric tonnes of live fish weight). The annual growth rate in aquaculture from 2001-2018 was 5% (FAO, 2020). In the ten top developing countries (mostly in Asia) that contributed 86% of the total global aquaculture production, the average annual growth rate of aquaculture was two to seven times faster than capture fisheries (Belton & Thilsted, 2014). Hence, despite the call for approaches to fisheries and aquaculture development to be nutrition-sensitive (Thilsted et al., 2016), the exponential growth of aquaculture into the future signifies it will continue to play a key role in meeting the demand for fish food in many countries worldwide (Shepon et al., 2020).

1.4. The role of small-scale aquaculture in contributing to food security and livelihood.

In Asia and Africa, where much of global aquaculture production originates, the majority of aquaculture production comes from SSA (Bhujel, 2009; Castine et al., 2017; Smith & Peterson, 2019). SSA, which is the focus of this thesis, has been defined as a form of aquaculture that involves limited assets, minimal operational costs, largely involve family labour and may be one of the multiple livelihood activities employed by a family group (Edwards, 2013). Asia and Africa provide positive examples of how SSA aquaculture can contribute significantly to food security and the livelihoods of rural communities. As Ahmed

and Lorica (2002) highlighted SSA can contribute to food and nutrition security through three pathways: a) income, b) employment, and c) consumption. First, SSA can lead to increased income. This improves the farmers' purchasing power to obtain other food types and material assets to improve their wellbeing. When SSA leads to increased fish consumption and boosts the nutrition status of households, their ability to generate income and be productive through self-employment also increases. Finally, SSA can increase fish consumption of farming households and fish supply to markets, which can reduce the price of fish and make it more accessible to poor consumers – especially those in developing countries where there is access to both capture fisheries and aquaculture sources of fish production (e.g., Belton et al., 2011b; Genschick et al., 2018).

Numerous empirical studies have shown the significance of SSA to poor households in terms of its contribution to their livelihoods and food security (Abdullah et al., 2016; Blythe, 2013; Castine et al., 2017; Duc, 2009; E-Jahan et al., 2010; Karim et al., 2017; Mulokozi et al., 2020; Pant et al., 2014). For instance, E-Jahan et al. (2010) showed in Bangladesh that households involved in SSA increased their fish consumption rate by 6.6% in two years from 2004 to 2006. This was an increase from 1.5 to 1.79kg/capita/month, due to the increased availability of fish. The authors also posited that the fish farming households generated USD 364 (Tk. 30,853) over three years, from 2003 to 2006 (an annual growth rate of 8%). The aforementioned study also showed that the adoption of improved fish farming practices enabled the generation of better incomes compared to other livelihood activities for participating households. In Tanzania, fish farming contributed an average annual income of USD222 in 2017 (a 13% contribution) to a total annual average household income of USD1,681 (Mulokozi et al., 2020). However, Mulokozi et al. (2020) further stated that such contributions were only minimal when compared to similar cases in Asia. This difference was ascribed to the level of SSA development in Africa, which has lagged behind Asia. Reasons for the slow progress of the African SSA sector included: 1) the sector was highly reliant on donor funding, hence, when donor support is withdrawn post-project sustainability becomes an issue, and 2) as a consequence of ineffective institutional support (Brummett et al., 2008; Mwanja et al., 2007).

SSA can also make important contributions to rural development – improving the financial conditions of rural households (Halwart et al., 2003; Villasante et al., 2015). For example, in the Ceará State of Brazil, households participating in SSA were shown to have increased their

income leading to better health and education opportunities when compared to non-farming households (Flores & Pedroza Filho, 2019). Nevertheless, Townsley (2013) has argued that for SSA to make tangible contributions to improved livelihoods and poverty reduction, SSA must be properly mainstreamed into the broader context of rural development activities. This implies SSA should only be considered as one potential activity in a suite of poverty reduction strategies (ibid).

1.5. The role of coastal fisheries and potential for small-scale aquaculture in PICTs

Currently, the PICTs that make up the Pacific Islands region are largely reliant on capture fisheries for their source of fish, and fishing is a major contributor to livelihoods through formal and informal employment (Gillett, 2016). Fisheries are also an intrinsic part of local and traditional cultures (Bell et al., 2009; Charlton et al., 2016; Ross et al., 2019; Secretariat of the Pacific Community, 2013). Capture fisheries encompass both coastal and pelagic fisheries (Gillett, 2016; Secretariat of the Pacific Community, 2013). Despite a number of PICTs, like Guam and Tonga, also popularly consuming beef, chicken, lamb, and mutton, fish remains an essential part of their diets (Charlton et al., 2016). Generally, across urban centres in most PICTs, fish accounts for 40-80% of animal protein intake, while this increases to 50-90% in the rural areas (Secretariat of the Pacific Community, 2008). A well-cited study by Bell et al. (2019) revealed that Pacific Islanders are among the highest consumers of fish globally, alongside countries in Southeast and East Asia (Mohan Dey et al., 2005). Estimates of fish consumption rates in PICTs showed that Pacific Islanders consumed between the range of 15.5 to 207 kg of fish/person/year (Gillett, 2016). Though maybe liable to underestimation, Gillett (2016) estimated subsistence coastal fisheries production across the Pacific Islands region to be 110,183 metric tonnes in 2014, worth around USD 235,788,102 (ibid).

Across the Pacific Islands region, unsustainable harvesting, increased pollution, agriculture and coastal development, plus compounding effects of climate change is placing additional pressure on coastal fisheries production (Bell et al., 2013; Bell et al., 2009; Lam et al., 2020; Secretariat of the Pacific Community, 2013). Any shortage of fish supply will likely impose negative consequences on the food security of Pacific Islanders, especially among specific groups like women and children where incidences of micronutrient deficiencies (e.g., stunting and wasting) are among the world's highest (Albert et al., 2020; Hughes & Marks, 2010).

Therefore, to ensure a continuous supply of fish for Pacific Islanders into the future, priority must be accorded to securing existing fish stocks (also rebuilding it) and coastal fisheries-based livelihoods through better management and cooperation between state and community. Co-management initiatives between the state and communities (Cohen et al., 2015; Ross et al., 2019) and the implementation of measures such as taboos, marine protected areas and periodically closed areas (Cohen & Foale, 2013; Foale et al., 2011) are areas that should be investigated and implemented where feasible. Fish aggregating devices can also assist with relieving fishing pressure on coastal resources (Albert et al., 2014; Bell et al., 2015a). Additional options to improve access to fish include the adoption of SSA (Bell et al., 2009) and diversion and re-distribution of tuna and by-catch from industrial fishing fleets to domestic markets (Bell et al., 2015b).

In several PICTs (e.g., Samoa, Vanuatu, and Solomon Islands) SSA has been promoted to supplement fish from coastal fisheries needed for livelihood development and food security (Adams et al., 2001; Amos et al., 2014; Ponia, 2010). In this thesis, I, therefore, explore SSA notably small-scale tilapia aquaculture which has been promoted in many PICTs as having the potential to not only help address future fish shortfalls but also to enhance livelihood opportunities and food security for many Pacific Islanders. This thesis will provide important empirical evidence that can help guide and inform policies and strategies concerned with small-scale tilapia aquaculture in the Pacific Islands region. The results presented in this thesis can be used by governments and development agencies to ensure that SSA in general, actually provides tangible contributions towards improving livelihoods and food security in the Pacific Islands region.

1.6. Overview of tilapia aquaculture in PICTs

Literature on tilapia aquaculture development in PICTs is scarce and scattered. However, tilapia[1] was among the first exotic finfish species introduced for inland aquaculture in the Pacific Islands region between the 1950s and 1980s. The introduction of tilapia into Papua New Guinea and Fiji was done to provide tilapia for rural fish farmers (Smith, 2007;

[1] Mozambique tilapia (*Oreochromis mossambicus*) was the first tilapia species introduced throughout the PICTs in the 1950s and 60s. Nile tilapia (*Oreochromis niloticus*), on the other hand, was only later introduced when PICTs realised the Mozambique tilapia was not performing well in SSA (Pickering, 2010). Hence, despite the Mozambique tilapia being introduced to most PICTs, and now being well established in the wild, only in Solomon Islands is the species farmed by rural fish farmers (Harohau et al., 2016).

Vereivalu, 1989), whilst in Vanuatu and Solomon Islands, tilapia was mainly introduced as a bio-controller for mosquito populations and to enhance fish stocks of inland fisheries (Eldredge & Humphries, 1994; Ponia, 2003).

It was after a series of failed aquaculture initiatives in the 1960s and 1970s and the realisation of the declining state of coastal fisheries production in the 1990s and early 2000s, that many PICTs began re-investing in the current phase of tilapia aquaculture (Ponia, 2010). Only Fiji and Guam have so far had their tilapia aquaculture sector transitioned into a commercially oriented one (ibid). For other PICTs (e.g., Papua New Guinea, Solomon Islands and Samoa), the sector is very much subsistence-oriented, where most tilapia production is for household food security (Harohau et al., 2016; Mather & Nandlal, 2013; Pickering, 2015, 2016; Smith, 2007).

In the Pacific Islands regional context, the development of SSA initiatives such as tilapia aquaculture is well supported from the national to the regional level in terms of development policies and strategies. For example, at the regional level, the *New Song for coastal fisheries – pathways to change: The Noumea Strategy* identified aquaculture as one of the alternative sources of fish production to meet the increasing demand for fish by the growing Pacific Islands population (Secretariat of the Pacific Community, 2015). At the national level, several PICTs have their own aquaculture development policies. In Fiji, its *Five-Year National Development Plan 2017-2021* stipulates a supporting policy for the growth of the aquaculture industry with a strategy focused on supporting SSA farmers for livelihood development and food security (Ministry of Economy Republic of Fiji, 2017). In Solomon Islands, one of the medium-term strategies under the National Development Strategy 2016-2035 highlights the development of aquaculture for commercial and rural community benefits as one priority (Ministry of Development Planning and Aid Co-ordination, 2016). These policies and strategies reflect the commitment of governments in supporting initiatives like small-scale tilapia aquaculture, as a means to supplement coastal fisheries fish production, contribute to livelihood opportunities and food security for Pacific Islanders.

1.7. Existing knowledge gap and significance of the research

SSA has the potential to contribute to livelihoods and food for rural communities. However, current evidence shows that the impacts and distribution of benefits from SSA are contingent upon variable factors (Arthur et al., 2013; Béné et al., 2016). For example, current evidence

shows that the benefits from SSA are strongly influenced by socio-economic factors which often results in benefits being captured by better-off farmers. This has been ascribed to the fact that better-off farmers have the necessary assets (e.g., income, access to loans, information, access to essential assets, etc.) to put them in the advantageous position of capturing most benefits when participating in SSA (Arthur et al., 2013; Béné et al., 2016; Thomas, 1994). Moreover, studies have highlighted that socio-cultural factors (e.g., gender roles) also influence who participate, and therefore who benefits from SSA (Belton et al., 2011a; Krause et al., 2020; Morgan et al., 2016; Smith & Peterson, 2019). Brummett et al. (2008) and Fernandez (2013) also identified that institutions like government agencies, non-government agencies and technical or research institutes are vital in ensuring the success of SSA in creating livelihoods for rural communities. Support provided by institutions via policy and strategy formulation, projects and extension services is vital in supporting the development and expansion of the sector. Yet, while this may be the case in Asia, in PICTs government mechanisms (e.g., extension services) are largely ineffective due to funding constraints, lack of coordination across sectors and among stakeholders, and corruption.

As previously mentioned, the positive impacts of SSA in the Pacific Islands region largely remains inconclusive (Adams et al., 2001; Amos et al., 2014; Hambrey & Nautilus, 2012). In this regard, the following points highlight the important gaps in knowledge that this thesis seeks to contribute to:

i. Currently, most empirical evidence available to date, showing the contributions of SSA (e.g., tilapia aquaculture) to livelihoods and food security is from Asia and to some extent African countries. There is still a paucity of empirical evidence reporting on SSA in the Pacific Islands region. While in Asia and Africa, SSA initiatives like small-scale tilapia aquaculture have been heralded for their contributions to livelihood and food security of rural communities, the success of SSA in one context cannot be easily translated or transferred into another context (Vandenberg et al., 2021). For this reason, I consider it essential to extend the focus on SSA and its impact on livelihood and food security to the Pacific Islands regional context – an area that has different social, cultural, economic, institutional and environmental characteristics than Asia or elsewhere. Studies by El-Sayed (2006) and Slater et al. (2013) have supported the need for attention on specific social contexts where SSA operates, i.e., to understand impacts but also opportunities and challenges.

ii. In PICTs, success in fish production from aquaculture (e.g., small-scale tilapia aquaculture) is attributed to the increased focus and investment on technical and technological aspects to increase production (Nandlal, 2012). However, we are seeing very limited evidence of these outcomes translated onto the livelihoods and food security of many Pacific Islanders. Increasingly, researchers and practitioners recognize that achieving sustainable aquaculture benefits for rural communities depends as much on contextual social dynamics as on improved aquaculture production technologies (Mather & Nandlal, 2013; Morgan et al., 2016; Slater et al., 2013; Thomas, 1994; Vandenberg et al., 2021). With the drive by Pacific Island governments and development agencies to develop tilapia aquaculture to enhance livelihoods and food security, it is, therefore, necessary to understand contextual social dynamics for the translation of SSA initiatives into tangible benefits. Also, so that appropriate policies and strategies are put in place to support tilapia aquaculture sector development in the Pacific Islands region.

iii. Not only are socio-cultural and economic factors important in determining the outcomes of SSA initiatives like small-scale tilapia aquaculture on livelihoods, but the roles of institutions are equally vital. Institutions, to some extent, can influence the utilisation of available assets by rural communities and the extent of external inputs. This is particularly relevant because in many PICTs, tilapia aquaculture is mainly introduced through external agents or institutions (Government, non-government organisations, and development agencies). Institutions are also vital in that they can provide the right environment through appropriate policies, legislation, and strategies to support the growth and expansion of SSA initiatives. Currently, there is a scarcity of empirical studies that have looked into this aspect in the Pacific Islands.

In many PICTs, there have been very limited studies exploring the social dimensions of small-scale tilapia aquaculture; similar to other aspects of tilapia farming (e.g., technical, economic, political, etc.) which are admittedly important areas for future research, however, are beyond the scope of this thesis. Addressing this information gap will make a substantial contribution to our knowledge of some underlying factors responsible for the minimal impact and limited expansion of small-scale tilapia aquaculture in the Pacific Islands' region. This study will also help contribute to expanding the current literature on SSA and livelihood beyond just Asia and Africa.

1.8. Thesis objectives and research questions

This thesis seeks to understand the social dimensions of small-scale tilapia aquaculture development in the Solomon Islands as well as the roles and challenges faced by various institutions supporting the sector's development.

In this context, the objectives of this thesis are reflected in four research questions that make up the four data chapters of this thesis. These questions are:

1) Which social factors are influencing the adoption of small-scale tilapia aquaculture by tilapia farmers in Solomon Islands?
2) What contribution has small-scale tilapia aquaculture made to the livelihoods and food security of tilapia farmers in Solomon Islands to date?
3) What contribution has small-scale tilapia aquaculture made toward household diets, relative to other ASFs consumed?
4) What roles, barriers, and opportunities are institutions facing in developing small-scale tilapia aquaculture in Solomon Islands?

1.9. Study site

The present research was conducted in Solomon Islands – a country within the Melanesian group of islands which also includes Papua New Guinea, Fiji, Vanuatu, and New Caledonia. Solomon Islands is located east of Papua New Guinea, north-east of Australia, and northwest of Vanuatu (FAO, 2016). According to provisional data available, in 2019, the country's human population was estimated at 721,455 (Solomon Islands National Statistics Office, 2020). Also in the same year, the country was ranked 151 out of 189 countries globally on the human development index (HDI)[2] (United Nations Development Program, 2020). The Household Income and Expenditure Survey 2012/13, however, revealed that 12.7% of the country's population are poor and living below the poverty line[3] (Solomon Islands National Statistics Office, 2015).

[2] The human development Index (HDI) is a key measure of human development (e.g., healthy, access to education and reasonable quality of life) (Sagar & Najam, 1998).
[3] Poverty in Solomon Islands is defined as the minimal level of expenditure needed to obtain basic food and non-food items, given the current food consumption pattern in Solomon Islands (Solomon Islands National Statistics Office, 2015).

The 2019 provisional census data revealed that 74% of the Solomon Islands population is rural-based with subsistence agriculture, forestry, livestock, handicrafts and food sales as common livelihood activities in the rural areas (Solomon Islands National Statistics Office, 2015, 2020). Major socio-economic and infrastructure development activities are concentrated in urban areas, while in rural areas, development is driven mostly by government projects and aid donor priorities (Faiau, 2013). Hence, there is minimal access to basic services, reliable utilities, transport and market access in rural areas leading to a high incidence of rural-urban migration (Solomon Islands National Statistics Office, 2020).

Like other PICTs, fish provides 94% of total ASFs in diets consumed by Solomon Islanders, with average fish consumption at 105kg of fish/person/year (Pinca et al., 2009). Weeratunge et al. (2011) and Pinca et al. (2009) estimated fish consumption in coastal villages in Solomon Islands to be as high as 98.6-111kg/person/year. However, the increasing population in rural areas is resulting in unsustainable fishing practices. While coastal and agricultural developments, combined with the effects of climate change also pose major problems for the future whereby it has been forecasted that there will be a shortfall of 6,000 to 20,000 metric tonnes of fish from capture fisheries per year by 2030 (Bell et al., 2009). This deficit of future fish supply has resulted in the national government and development agencies promoting small-scale tilapia aquaculture as one option that can fill this future shortfall (Cleasby et al., 2014; Harohau et al., 2016).

I conducted my fieldwork in Malaita Province on two separate occasions – in 2017 (May to June) and in 2018 (November to December). Malaita Province provided the ideal region for my research based on the following characteristics: a) it contains the highest population of all provinces in Solomon Islands – 173,347 (or 24%) of the total Solomon Islands' population in 2019 (Solomon Islands National Statistics Office, 2020) and as such is likely to experience food shortfalls first; and, b) was the focus of an external institution working on the development of small-scale tilapia aquaculture as part of a wider development and research agenda; the Australian Centre for International Agricultural Research (ACIAR) projects 'Aquaculture and Food Security in the Solomon Islands' (FIS/2009/061) and 'Developing inland aquaculture in the Solomon Islands' (FIS/2010/057). The vast majority of the population on Malaita (95%) are concentrated along the coast (within 5km off coastal margins), and subsistence fishing and gardening are common livelihoods while engagement

with the formal economy is limited to few income-generating opportunities limited to the sale of garden produce, cash-crops, trading of marine resources, government and casual employment (Connell, 1984; Foale et al., 2011; Schwarz et al., 2013). In some localities, income is generated through royalty payments and short term benefits from extractive industries like logging (Minter et al., 2018).

I collected data from rural farmers in six farmer clusters[4] around Auki (the provincial administrative centre of Malaita Province; Figure 1**).** These six farmer clusters host one of the largest informal networks/groups of small-scale tilapia farmers in the country. They were based on a pre-existing categorisation and arrangement from the ACIAR project of which I was part of the project team. The ACIAR project was implemented by WorldFish and the Ministry of Fisheries and Marine Resources from 2011-2015 and supported collaboration between technical staff, local fish farmers and stakeholders to research and develop the best mechanism for small-scale tilapia aquaculture, based on the available Mozambique tilapia species (Sulu et al., 2015a). After the ACIAR project ended, there remained an informal network of small-scale tilapia farmers – some of whom were existing fish farmers, while others took up tilapia farming only after the project ended (personal communication with aquaculture project staff; Sulu et al., 2015). Accessibility to these small-scale tilapia farmers was also an important consideration for conducting fieldwork with them – given the limited resources allocated for the fieldwork (e.g., logistics, finance, and time).

[4] *Clusters*, in this context, refer to pockets or groupings of tilapia farmers distributed throughout the study region. Hence, a cluster was devised by grouping tilapia farmers within proximity of each other (geographically) in a particular group, and so forth. Umesh et al. (2010) also used similar cluster model to group their fish farmers, but the reason for their grouping was for effective resource sharing (e.g., water and land) among farmers. In the case of this study, the clusters enabled ease of accessibility by project officers when delivering extension services to farmers. This strategy was formulated by a previous tilapia aquaculture development project (or the ACIAR FIS/2010/57 project) as a means of effective extension service delivery, addressing the problem of farmers' geographical spread.

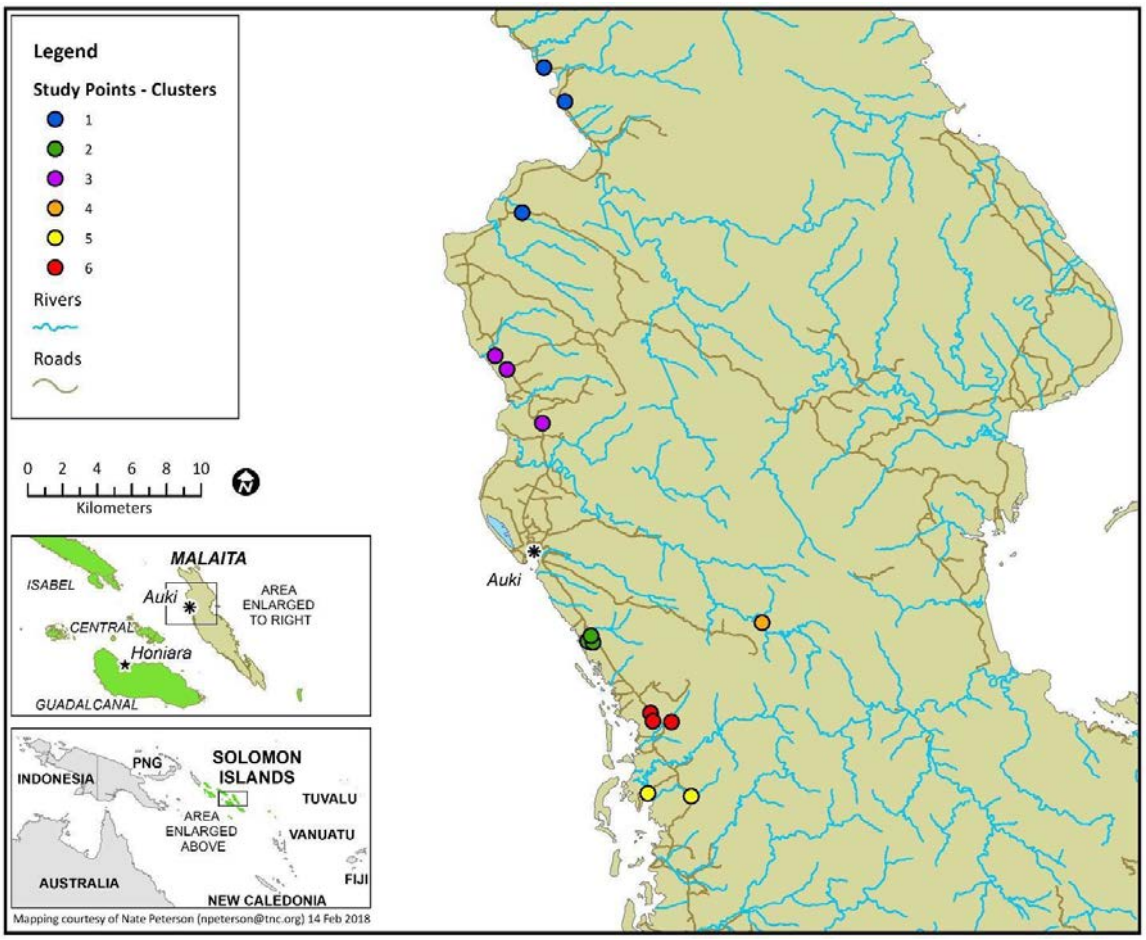


Figure 1: Study site in Malaita Province, Solomon Islands. Note: The different coloured dots represent the six farmer clusters.

My interviews with most institutions were held in Honiara, the nation's capital located on the island of Guadalcanal. The exception to this was WorldFish which also has an office in Auki. Honiara is the central business hub and is also the largest urban centre in Solomon Islands (Moore, 2015; Rodil & Mias-Cea, 2014). Honiara also hosts the international ports (both air and sea), the central and Guadalcanal Provincial governments respectively, the main hospital, several schools, and other important services (Rodil & Mias-Cea, 2014).

I conducted two field trips to the study site in Malaita Province between 2017 and 2018. In the initial trip from May to June 2017, I visited individual small-scale tilapia farmers and non-tilapia farmers and interviewed staff from various institutions in Honiara. In my second field trip from November to December 2018, I returned to Malaita Province and collected data from household heads (husband/father and wife/mother) instead of individual farmers as in my first field trip.

1.10. Thesis Outline

The results of this thesis are explored in the following process (Figure 2).

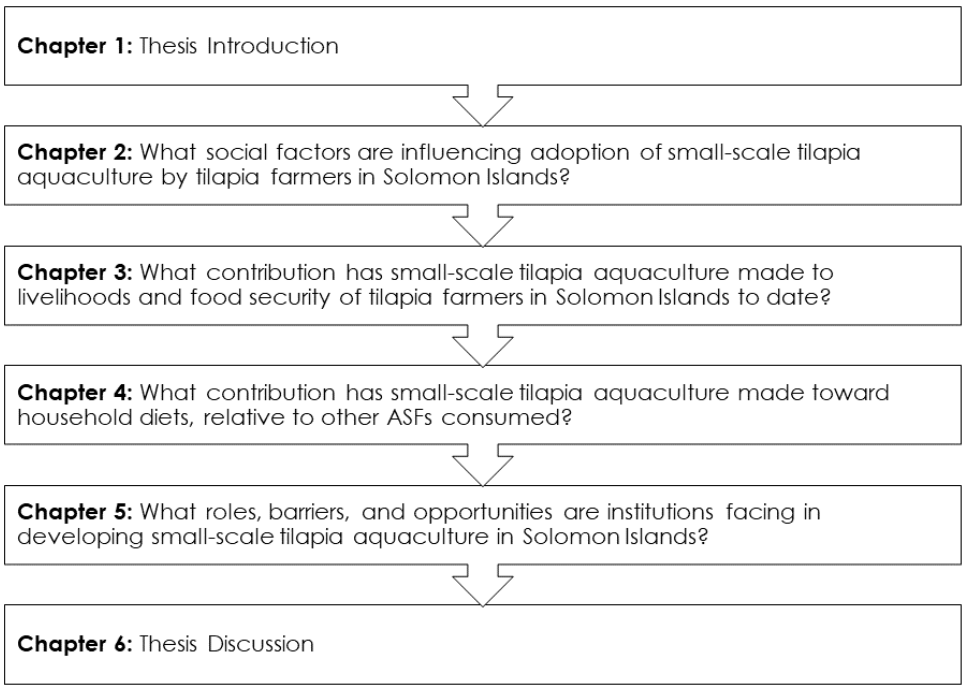


Figure 2: Flow chart of the thesis chapters.

This chapter (Chapter 1) provided a platform of information for which this thesis is based on. For instance, it sets the scene for this thesis, then it identifies the knowledge gap where the thesis seeks to contribute to and the locality in the PICTs where the research was conducted.

Chapter 2 specifically looked at the factors driving the adoption of small-scale tilapia aquaculture in Malaita Province, Solomon Islands. In this chapter, I use the Diffusion of Innovation (DOI) Theory to identify three independent variables: socio-economic attributes, communication channels and attributes of the innovation to explore their influence on adoption and non-adoption (as dependent variables) of small-scale tilapia aquaculture. I then use the classification and a regression tree to explore the influence of the independent variables on adoption and non-adoption. The results of this analysis show that socio-economic attributes had the highest influence on the adoption of small-scale tilapia aquaculture. Based on these results, I highlight that small-scale tilapia aquaculture development initiatives in rural communities need to pay closer attention to the local contexts that influence the uptake of these initiatives.

Chapter 3 uses the Sustainable Livelihood Framework (SLF) to guide my analysis of the impacts of small-scale tilapia aquaculture on rural livelihoods. Specifically, I looked at the contribution of SSA to fish farmers' five livelihood assets (i.e., physical, natural, social, financial, and human), livelihoods and food security. Briefly, the results showed more tilapia farmers were satisfied with small-scale tilapia aquaculture's contribution to their human and social assets, but less so to their physical, natural and financial assets. It was also determined that small-scale tilapia aquaculture contributed insignificantly to overall livelihoods and food security. Subsequently, the results show that the current Mozambique tilapia species used for aquaculture is unable to contribute significantly to rural livelihoods and food security unless a species of tilapia that performs better in aquaculture is sourced and distributed.

Chapter 4 sought to provide an understanding of the contribution of tilapia to household diets by comparing those households that farm tilapia and those that do not. I used a 24-hour food consumption diary over a seven-day period combined with a seasonal food consumption recall method with 68 households (36 small-scale tilapia farming households and 32 agricultural farming households). Results from this research showed that the ASF consumed by most households was predominantly processed fish products (which include canned tuna, canned sardine and canned mackerel) followed by marine fish (reef fish and pelagic fish). Per capita fish consumption was estimated at 50.4 ± 9.8kg/year, whereby fish consumed comprised of 71.4% marine fish, 25.9% processed fish products, 2.6% freshwater species, and only 0.1% tilapia. Overall, the consumption of marine fish will still play an important role as an ASF in rural communities, while processed fish products seem to be the preferred alternative because of their cost-effectiveness, accessibility and long shelf life. Notably, this chapter showed that tilapia from small-scale tilapia aquaculture contributed negligibly to fish farmers' household consumption; due to the influence of locality and preference which are limiting the contribution of tilapia from aquaculture to local food security.

Chapter 5 explored the perspectives and experiences of relevant institutions in supporting small-scale tilapia aquaculture development in Solomon Islands. I interviewed several institutions on their current roles and milestones they had achieved so far in supporting small-scale tilapia aquaculture, including barriers and opportunities. Technical support for fish farmers and collaboration and partnership between institutions were the two most common roles played by the institutions interviewed (Ministry of Fisheries and Marine Resources,

WorldFish and Adventist Disaster Relief Agency), while broader awareness and increase in technical knowledge of small-scale tilapia aquaculture were the most mentioned milestones. Two important barriers identified of the small-scale tilapia aquaculture sector were the use of Mozambique tilapia and the current limited opportunities for marketing the farmed tilapia species. The current government's plan to introduce Nile tilapia could alleviate some of these issues and provide an opportunity forward.

Chapter 6 is the concluding chapter and presents the overarching discussion of my thesis, and its contribution to the need to understand the social dimensions of small-scale tilapia aquaculture in the Pacific Islands regional context, using the initiative in Malaita Province as the central example. Discussion points explore how the current initiative intended to promote the small-scale tilapia aquaculture sector in Solomon Islands can be used to ensure future initiatives actually assist with supporting livelihoods and food security. I also highlight areas that can be considered for further research.

2. Chapter 2: Social factors influencing adoption of small-scale tilapia aquaculture in rural Solomon Islands.

2.1. Preface

This chapter explores the factors influencing small-scale tilapia aquaculture adoption among rural fish farmers in Malaita Province, Solomon Islands. Understanding these factors is imperative to ensure initiatives aimed at promoting small-scale tilapia aquaculture tangibly produce benefits that support livelihoods and food security. In my previous experience working as an extension officer under the ACIAR project, I observed strong interest and enthusiasm among rural communities to practice small-scale tilapia aquaculture throughout the project. This was reflected by the growing number of tilapia farmers directly involved in the project (Sulu et al., 2015a). However, after the project ended in 2015, only a handful of individuals were able to sustain tilapia farming over time. Some people who initially took up the activity later lost interest, while others, despite a lot of enthusiasm to practice small-scale tilapia aquaculture, never took up the initiative. This prompted my interest to further investigate and understand what is driving the adoption of small-scale tilapia aquaculture in Malaita Province. Using the Diffusion of Innovation (DOI) as an analytical framework, I selected three broad variables to investigate the factors influencing adoption (as independent variables) and then used the classification and regression tree to model their influence on adoption and non-adoption (i.e., dependent variables). A version of this chapter was published as: Harohau, D., Blythe, J., Sheaves, M., & Diedrich, A. (2020). Uneven adoption of tilapia aquaculture in rural Solomon Islands. *Aquaculture International*. https://doi.org/10.1007/s10499-020-00577-2

2.2. Introduction

Food and nutritional insecurity among Pacific Islanders are expected to worsen in the near future (Sievert et al., 2019). Processed foods high in carbohydrates and fats, including rice, are being increasingly imported and are eroding once healthy traditional diets (Secretariat of the Pacific Community & CSIRO, 2011; Sievert et al., 2019; Snowdon et al., 2013). Limited income and rapid population growth are also contributing factors, as they reduce access to nutrient-rich food especially for those in urban centres who rely mainly on local markets (Connell, 2015). As a result, malnutrition among vulnerable groups, such as women and children, remain unacceptably high across PICTs (Secretariat of the Pacific Community & CSIRO, 2011). For instance, recent estimates from Fiji, Nauru, Solomon Islands, Tonga,

Tuvalu, and Vanuatu suggest that 18% of children under 5 years old are stunted and 38% of pregnant women are anemic (United Nations Children's Fund, 2017). These numbers are higher in Solomon Islands, where childhood stunting affects an estimated 33% of children under 5 years of age (ibid). Such increased incidence of food insecurity and malnutrition presents significant challenges for meeting global nutrition targets (e.g., SDG 2.2 aims to end all forms of malnutrition by 2030) and exerts pressure on many PICTs already under-resourced health services, thus further limiting individual and national development.

Fish provides an important source of protein and micronutrients and can contribute to food and nutritional security (Bogard et al., 2016; Hicks et al., 2019). Yet, most fish in PICTs are largely supplied by coastal fisheries, which are experiencing a decline in supply due to unsustainable fishing efforts combined with the effects of climate change (Bell et al., 2009; Secretariat of the Pacific Community, 2013; Valmonte-Santos et al., 2016). Fish from SSA can, therefore, provide an alternative source of animal protein and essential micro-nutrients (Amos et al., 2014; Nandlal, 2012). Small-scale tilapia aquaculture has been promoted as a strategy to help address the food and nutritional insecurity challenge in the Pacific Islands region (Amos et al., 2014; Pickering, 2010).

Despite the potential contribution of small-scale tilapia aquaculture to food and nutritional security (Pickering, 2010), its adoption by rural households in the Pacific Islands region remains low (Blythe et al. 2017). In Solomon Islands, the Government's National Tilapia Action Plan (2010-2015) acknowledges lack of knowledge and skills to farm tilapia; tilapia's slow growth and high fecundity; difficulty sourcing feed; and limited demand for tilapia compared to marine fish as challenges facing the sector (Ministry of Fisheries and Marine Resources, 2010). Yet these highlighted challenges only focused on biological and technological aspects, with limited attention to the social dimensions of SSA. Amos et al. (2014) suggest that such limited engagement with the social dimensions of aquaculture also extends to other current aquaculture development initiatives in the Pacific Islands region. People's perceptions, choices and assets are central to the adoption of aquaculture and influence the potential of aquaculture to deliver sustainable development outcomes (Slater et al., 2013). As such, an understanding of the social dimensions that shape the adoption of aquaculture is as important as understanding the biological and technological dimensions to ensure its potential positive impacts are realized (Krause et al., 2015; Slater et al., 2013). Towards this aim, I draw on the DOI theory to explore the influence of context-specific factors

on the adoption of small-scale tilapia aquaculture.

In this chapter, I examine the influence of socio-economic attributes, communication channels, and attributes of the innovation on the adoption of small-scale tilapia aquaculture in Malaita Province. Importantly, findings from this chapter can inform SSA development policies and strategies of the Government of Solomon Islands, and other PICTs to ensure the sector is supporting appropriate initiatives that contribute to supporting livelihoods and food security.

2.2.1. Diffusion of Innovation

Diffusion of Innovation theory is a conceptual framework that explains how an idea, behaviour or product, referred to as an innovation, gets adopted and spreads through a social system over time. The theory proposes that adoption behaviour, including the time it takes individuals to adopt an innovation, depend on both the socio-economic characteristics of the individual and the attributes of the innovation (Padel, 2001; Pannell et al., 2006; Rogers, 2003). The theory suggests that socio-economic characteristics of the adopter, along with their personal values and communication behaviour will affect the time taken to adopt the innovation, relative to other members within a social system (e.g., their innovativeness). Moreover, the way in which information about the innovation is communicated to potential adopters (e.g., mass or interpersonal) can also affect adoption. As such, the theory recognises the potential role and influence of change agents such as extension or program officers (Rogers, 2003). The attributes of the innovation, which affect the rate of adoption, include its relative advantage, compatibility, complexity, trialability and observability. DOI theory, therefore, provides a useful heuristic for the purpose of this chapter in that it provides a holistic view of the innovation adoption process.

While the majority of DOI research has been conducted in the agricultural sector (Glendinning et al., 2001; Kuehne et al., 2017; Peshin et al., 2009), very little has been applied to investigate the adoption of innovations in SSA (Blythe et al., 2017).

This chapter explores the potential influence of three components of the DOI on the adoption of small-scale tilapia aquaculture in Solomon Islands: 1) socio-economic attributes of adopters, 2) communication channels, and 3) attributes of the innovation. Understanding

people's perceptions of the innovation (e.g., small-scale tilapia aquaculture) and their socio-economic attributes can help explain why rural people despite expressed interest in small-scale farming aquaculture, never widely adopted the innovation (Cleasby et al., 2014). Understanding the relative influence of different communication channels and sources of information may also help to understand why, despite the availability of informational materials (e.g., pamphlets, brochures and posters) and the presence of existing tilapia farmers in the study site, there still seems to be slow adoption and limited expansion of small-scale tilapia aquaculture (Blythe et al., 2017). Overall, these three broad independent variables all have had an influence on small-scale tilapia aquaculture adoption in rural Solomon Islands.

2.3. Methods

2.3.1. Participant Selection

In the six tilapia farming clusters (see section 1.9 for details of study site), non-probability sampling strategies were used to identify participants for the survey (Ritchie et al., 2013). The sample population were characterized into two groups: small-scale tilapia aquaculture adopters and non-adopters. Small-scale tilapia aquaculture adopters were defined as individuals who are active tilapia farmers or may have attempted tilapia farming before but may have discontinued or shifted to other livelihood activities. In contrast, non-adopters were those who never pursued further tilapia aquaculture.

Purposive sampling was used to achieve a quota sample of 40 small-scale tilapia aquaculture adopters and 40 non-adopters (Etikan et al., 2016). This quota is estimated to represent 69% and 90% of the population of each group respectively in the study site (Harohau et al., 2016).

2.3.2. Data Collection

Data were obtained through face-to-face surveys with individual small-scale tilapia aquaculture adopters and non-adopters at their respective dwellings across the six clusters. The survey questions were informed by DOI theory, whereby specific independent variables used in the analysis were derived from the three components of the theory described above: socio-economic attributes, communication channels and attributes of the innovation. Data collected included a mixture of nominal, ordinal, and scale levels of measurement.

Surveys were conducted face-to-face in the first round of fieldwork from 16th May to 21st June

2017 in Solomon Islands *Pidgin* (the lingua franca for Solomon Islands). Surveys were administered with the help of a trained field assistant who was fluent in both Solomon Islands *Pidgin* and the local dialect (predominantly kwara'ae dialect). Participants were surveyed depending on their availability, willingness, and consent to be interviewed. Each survey lasted between 35 to 70 minutes.

2.3.3. Data Analysis

Survey data were collated in Microsoft Excel™ software, before being exported into the SPSS statistical package (version 24 & 25), coded into respective levels of measurement (e.g., nominal, ordinal, scale) for exploratory (descriptive statistics) and the classification tree analysis. A brief description of the specific variables measured and analysed are provided in Table 1.

For the data coded in SPSS, a classification tree analysis to explore the relationships between the predictor variables and the dependent variable was employed (i.e., adoption or non-adoption). The classification tree analysis was used because the dependent variables used were binary, because of its flexibility in exploring both categorical and numeric data, and its ability to do data description and predicting patterns (De'ath & Fabricius, 2000; Loh, 2011). Classification tree analysis does not necessarily demand normality and homogeneity of variance between variables, and it facilitates multiple variable interactions. With its recursively partitioning of data thus yielding a set of outcomes presented graphically, it ensures an easy interpretation of the output data set (ibid).

Table 1 The three categories informed by DOI theory, and brief descriptions of their specific independent variables measured.

Broad category	General variables	Specific independent variables	Description	Measurement scales
Socio-economic Attributes	a. Socio-economic attributes	Age, marital status, household size, MSL, literacy level, education, leadership role, land ownership, household subsistence level, number of meals households consumed/day. Total number of household livelihood activities, number of activities for food, activities for income, household weekly income, household weekly expenditure	MSL included the household assets (e.g., radio, generator, solar, transport, etc.). Using PCA, this was reduced to two components, basic and high MSL (explained by 52% and 21% of total variance respectively) which was used for further analysis. Household subsistence level was measured by the percentage of food locally produced and consumed by households (as opposed to sold for income). The number of meals household consumed/day measures household food security level. Also measured is the total activities household derive their food and income from (quite a number of livelihood activities overlap in this regard. E.g., can be for food or income).	Age, MSL, household size, household subsistence level, number of meals consumed/day, the total number of livelihood activities, number of activities for food and income, household weekly income and expense (Scale) Marital status, literacy level, leadership, land ownership (nominal) Education, (ordinal)
Communication channels	a. Communication channel b. Communication/Information source	a. Word of mouth, written form, farm demonstration, others b. Relatives, lead farmers, friends, project officers, and others.	In total, four communication channels and five information sources were proposed to be used in the study sites.	All variables (Nominal)

Attributes of innovation	a. Relative advantage[5] b. Complexity[6] c. Compatibility d. observability	a. relative benefits of tilapia farming b. Why tilapia farming was not broadly adopted. c. If tilapia farming violates custom norms, and if it imposes an additional burden to existing livelihood demand. d. Have you observed benefits of tilapia farming?	For relative advantage and complexity see the explanation below detail. For compatibility, a 3-point scale of the level of agreement was used. For observability, a binominal response of "yes" or "no" was used if respondents observed tilapia farmers benefiting.	Relative advantage, complexity, and observability (Nominal) Compatibility (Ordinal).

Here, responses were generally collated into common themes, and only those responses that define relative advantage and complexity of tilapia farming (following Blythe et al., 2017) had their frequencies totalled to represent relative advantage and complexity in descriptive analysis and SPSS as two independent variables.

[5] Relative advantage was derived from collation of qualitative responses from the question that looked at the benefits observed from tilapia farmers/farming.
[6] Similar, Complexity was derived from qualitative responses from the question that looked at reasons why tilapia farming was not taken up by potential, aspiring farmers.

2.4. Results

2.4.1. Descriptive analysis

2.4.1.1. Socio-economic attributes

The descriptive analysis showed that both small-scale tilapia aquaculture adopters and non-adopters supported an average of six to seven people in their households. Tilapia farmers were all male, and engaged in between four to five livelihood activities, with tilapia farming being one of them (Table 2). Other attributes differed between the two groups. For instance, small-scale tilapia aquaculture adopters were older, had more formal education and thus literacy, they had higher incomes potentially due to being engaged in more livelihood activities, and most were married and held leadership positions (which would tend to suggest a high social status). In contrast, non-adopters had higher MSL, owned more land, and were more subsistence-oriented.

Table 2 Mean and frequency of the independent variables under socio-economic characteristics, communication, and attributes of innovation.

Category	**Variables**	**Adopters (N=40)**	**Non-adopters (N=40)**
		Mean ± (SE)	
Socio-economic attributes	Age (years)	45 ± (2.5)	40 ± (1.9)
	Household size (# of people)	6 ± (0.5)	7 ± (0.7)
	Subsistence level (%)	55.3 ± (4.0)	62 ± (4.7)
	Number of livelihood activities	5 ± (0.2)	4 ± (0.2)
	Weekly household income (SBD)*	$1,134.2 ± (242.8) *(USD$140.30)*	$895.5 ± (142.4) *(USD$110.77)*
	Weekly household	$88.4 ± (22.8) *(USD$10.95)*	$108.5 ± (34.3) *(USD$13.43)*
	Basic MSL	0.1 ± (0.2)	-0.1 ± (0.2)
		Frequency (%)	
	Sex (male)	100	100
	Marital status (Married)	95	88
	Literacy level	83	75
	Education	88	83
	Leadership positions	58	53
	Land ownership	75	85
Communication channels	Word of mouth	63	80
	Farm demonstration	55	33
	Written form (e.g., pamphlets)	25	10
	Others	8	0
Communication Sources	Lead farmers	25	43
	Project/extension officers	25	8
	Friends	5	5
	Relatives	55	45
	Others	5	5

Attributes of innovation	Relative advantage	5	13
	Compatibility I. With socio-cultural norms II. With existing livelihood demand	I. 95 II. 50	I. 95 II. 58
	Complexity	38	25
	Observability	48	58

*Currency conversion from SBD to USD is calculated from https://www.xe.com/currencyconverter/ on the 25th of August 2021.

2.4.1.2. Communication Source and Channel

Of the five communication sources (Table 2), *relatives* were the most common source across both small-scale tilapia aquaculture adopters and non-adopters. For adopters, relatives were followed by lead farmers and extension officers respectively, then friends, followed by others (e.g., exchange visits to other small-scale tilapia aquaculture initiatives observed outside of the province). For non-adopters, relatives were followed by lead farmers, extension officers, then friends followed by others (e.g., saw the idea of farming tilapia outside of Malaita Province; and initiating small-scale tilapia aquaculture without any prior information or knowledge).

For the channel by which small-scale tilapia aquaculture information was communicated, the majority of tilapia aquaculture adopters and non-adopters relied on *word of mouth*. This was followed by farm demonstrations, written forms (e.g., pamphlets and posters), then others (e.g., workshops and observing others) across both groups.

2.4.1.3. Attributes of the Innovation

Most (95%) farmers in both groups perceived small-scale tilapia aquaculture to be highly compatible with local norms (Table 2). However, only 50% of adopters and 58% of non-adopters considered small-scale tilapia aquaculture to be compatible with their existing livelihood demands.

Small-scale tilapia aquaculture had a low relative advantage as indicated by both groups (i.e., the degree to which it was perceived better than similar activity or one it supersedes), low complexity (the degree by which small-scale tilapia aquaculture was difficult to understand or implement) and was slightly more observable (the degree by which small-scale tilapia

aquaculture and associated benefits were visible to others) to non-adopters, than to adopters.

2.4.2. Classification Tree Analysis

Classification tree analysis was performed to explore the relative influence of the independent variables (Table 1) on small-scale tilapia aquaculture adoption and non-adoption. Age showed the highest likelihood of influencing adoption (Figure 3). Age was followed by the subsistence level of households (measured by the percentage of food produced and consumed by households) and then MSL. Age was split into ≤57 (young) and >57 (older) years at an improvement level of 0.050. Though more adopters (n=9) than non-adopters (n=1) were observed in the >57 age category, this did not match the high number of both adopters and non-adopters in the ≤57 age category. Thus, caution should be taken when interpreting this output, in that though there is a possibility that some small-scale tilapia aquaculture adopters were older, the majority still fell into the younger age category. Moreover, this result may also be indicative of a broader demographic trend of relatively fewer people being over the age of 57.

The young age category was further split by household subsistence level at improvement 0.043, into less subsistence-oriented households (≤60%) and more subsistence-oriented (>60%). Here, small-scale tilapia aquaculture adopters were likely to be less subsistence orientated. For the less subsistence-orientated households, MSL resulted in two terminal nodes: higher MSL (≤-1.03) (i.e., less basic) and more basic MSL (>-1.03). This suggests that small-scale tilapia aquaculture adopters were more likely to have basic MSL than non-adopters. Cautiously, no adopters (n=0) and a minimal number of non-adopters (n=5) were in the higher MSL category compared to a larger number of both in the basic MSL category. As such, there is a likelihood that those members of the community who have higher MSL will be non-adopters, even though a larger proportion overall are in the basic MSL category. Finally, more subsistence-oriented households were further split by age (at improvement=0.031) into two categories: ≤39.5 (young) and >39.5 (older/mature aged). Hence, in more subsistence-orientated households, there is a propensity for non-adopters to be younger than adopters.

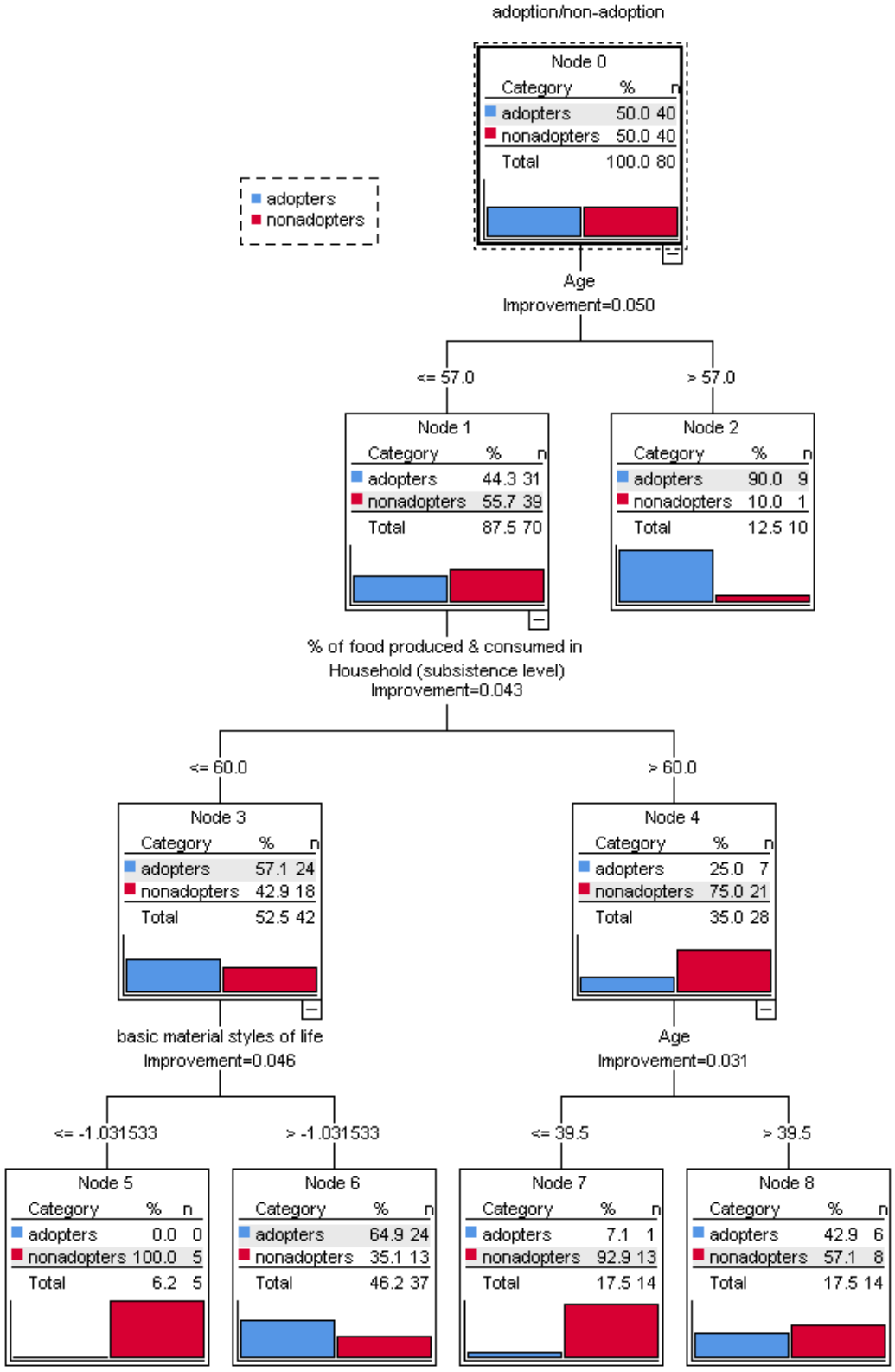


Figure 3: Classification tree of the influence of socio-economic attributes, communication channels and attributes on small-scale tilapia aquaculture adoption and non-adoption. The four splits in the model show the variables that determine the distribution of the dependent variable as displayed in the

subsequent nodes. The misclassification (Resubstitution) risk for the model was 26.3% (std. error 0.049). Criteria were set to 10 sample folds, with Growth limit set at 10 for parent node and 5 for child node.

2.5. Discussion

With food insecurity predicted to increase across PICTs like Solomon Islands, small-scale tilapia aquaculture has been proposed as a means to support livelihoods and improve food security (Amos et al., 2014; Pickering, 2010). Despite small-scale tilapia aquaculture's potential contribution to livelihoods and food security, the relatively low adoption has limited its contributions to date in Malaita Province. One of the recognised obstacles for SSA is the limited understanding of the social factors affecting the interests and capabilities of rural fish farmers to adopt the activity (Slater et al., 2013). Using the DOI Theory, this chapter looked at the influence of socio-economic attributes, communication channels, and attributes of innovation on the adoption of small-scale tilapia aquaculture in Malaita Province. The results showed that small-scale tilapia aquaculture adopters and non-adopters differed in most of their socio-economic attributes, whereby adopters tended to be older, less subsistence-oriented and with lower MSL than non-adopters. Next, both groups received most of their information about small-scale tilapia aquaculture through informal channels, including relatives and via word-of-mouth, as opposed to more formal channels such as extension agents and written pamphlets. While the innovation was compatible with socio-cultural norms and livelihood demands, its relative advantage and observability in comparison to other livelihoods activities were perceived as low. The classification tree model showed socio-economic attributes (e.g., age, subsistence level of households, and MSL) to be the most influential variables on small-scale tilapia aquaculture adoption. These findings have important implications for rural small-scale tilapia aquaculture development in Solomon Islands and across the Pacific Islands region.

First, socio-economic factors were found to influence the adoption of small-scale tilapia aquaculture more than communication channels and attributes of the innovation. This finding was consistent with other studies which also found similar socio-economic factors (e.g., farm size, wealth, age, access to credit, etc.) to influence the adoption of comparable agriculture and aquaculture technologies (Akudugu et al., 2012; Blythe et al., 2017; Diedrich et al., 2019; Mandima, 1995; Pandey & Upadhyay, 2012; Sileshi et al., 2019). In this study, age was identified as having the strongest influence on adoption and non-adoption, where older

farmers were likely to be adopters. This result was consistent with findings by Blythe et al. (2017); Mignouna et al. (2011); Uhunamure et al. (2019) and Wetengere (2011) who showed that older farmers were likely to be the innovation adopters. This is because older farmers tended to spend more time at home giving them more free time to adopt and that they also prefer innovations that require low maintenance. Yet other studies found younger farmers were more likely to adopt innovations due to their risk-taking nature, and longer planning prospects; despite being potentially limited in their human and financial capacity (Asfaw & Neka, 2017; Donkor et al., 2019; Kapanda et al., 2003; Ngoc et al., 2016; Ofuoku et al., 2008). Furthermore, other studies have also shown that age does not influence adoption (Akudugu et al., 2012; Tenge et al., 2004). Altogether, these varied findings imply the influence of age on adoption is highly contextual and may depend on the type of innovation in question. In this current study, age also featured as having a weaker influence on small-scale tilapia aquaculture adoption and non-adoption at the terminal node of the model, whereby individuals younger than 39.5 years old in subsistence-oriented households were less likely to adopt. This may be because younger individuals frequently move in and out of their villages and are more inclined to undertake better income-generating opportunities (e.g., diving for sea cucumber) when they were available (Wetengere, 2011). Age, therefore, may not possess a consistent relationship with innovation adoption.

Second, the adoption of small-scale tilapia aquaculture is likely to be done by males only. The descriptive analysis revealed all tilapia aquaculture adopters were male, which implies adoption (and therefore its associated benefits) in the study context may be gendered, and not reaching marginalised groups (e.g., women and children). This underlines an important relationship between equity and adoption that can potentially constrain the fair distribution of benefits from small-scale tilapia aquaculture, while also demonstrating the unique needs of vulnerable members of the community (Haider et al., 2018; Kruijssen et al., 2018; Makate et al., 2019). Consideration of equity is not only essential in identifying farmers' capacity to adapt and benefit from small-scale tilapia aquaculture but also to avoid SSA initiatives running the risk of further exacerbating marginalisation of certain groups within the communities, such as women (Diedrich et al., 2019). Overall, this issue of equity reinforces the need for a more comprehensive understanding of the socio-economic attributes of aspiring adopters when planning SSA initiatives (Belton & Little, 2011; Lado, 1998; Morse & McNamara, 2013; Munasinghe et al., 2010; Naegel, 1995; Senff et al., 2018). While this research found males dominantly taking up small-scale tilapia aquaculture as a livelihood

activity in Malaita Province, in some PICTs like Fiji and Papua New Guinea women are becoming actively involved in fish farming alongside men in the sector as well (Pacific Community et al., 2018).

Third, the adoption of small-scale tilapia aquaculture also seems to favour less subsistence-oriented farmers with more basic MSL. While less subsistence-oriented and more basic MSL were shown by the model to influence small-scale tilapia aquaculture adoption; the relative influence of this variable and the sample distribution on this split suggests this result may be negligible. Consequently, caution must be taken when interpreting the split outcome. These two variables indicate that the availability of time and motivation (e.g., through incentives such as start-up funds or tools) may explain why farmers adopted the innovation. For instance, farmers in households who spend less time on subsistence activities may have more available time to invest in additional livelihood activities such as small-scale tilapia aquaculture. Whereas farmers in better-off households may be content with what they currently have, and subsequently less motivated to adopt an additional livelihood activity. This finding was consistent with Diedrich et al. (2018) and Asfaw and Neka (2017) in their respective studies of sport-fishing tourism in Papua New Guinea and adoption of soil and water conservation practices in Ethiopia respectively. Further research may be required to establish any significant relationship between time, motivation, and adoption of competing livelihood activities. It is, therefore, imperative for policymakers, extension service officers, and development agencies to be conscious of these potential socio-economic attributes (including the ones already mentioned) in order to tailor assistance accordingly to fish farmers' context and capacity. This may also require a collaborative effort from all relevant stakeholders to minimise prominent contextual barriers to adoption such as time available to invest in other livelihood activities, or possible diversion of physical assets investments from small-scale tilapia aquaculture to other viable livelihood activities (Curry et al., 2015; Slater et al., 2013).

Lastly, rural farmers dominantly rely on interpersonal channels as opposed to extension services or written forms to communicate information about small-scale tilapia aquaculture. This chapter has revealed that relatives as a communication source and word of mouth as a communication channel were popular amongst fish farmers to communicate tilapia farming information. This is a likely indication that communication in the local context is more effective amongst people closely related or have similar backgrounds through kinship, social status, geographical locality or have the same dialect (Barnes et al., 2016; Hoa et al., 2009;

Rogers, 2003). This may be so because many rural fish farmers are more comfortable and confident conversing with those similar to them (e.g., relatives), as opposed to those dissimilar to them (e.g., change agent or opinion leader). Rogers (2003) coined this the homophilous aspect of communication networks, whereby people with similar backgrounds not only frequently communicate with each other but do so effectively because of their shared issues and goals. This finding was consistent with a number of studies that highlight communication about innovations occurs within close social networks (Bandiera, 2006; Kiptot et al., 2006; Mittal & Mehar, 2016; Nakano et al., 2018; Superio et al., 2018; Vishnu et al., 2019). However, these are contrary to studies by Adolwa et al. (2012) and Nyambo and Ligate (2013) who highlighted with the adoption of soil fertility management and cashew production in Kenya and Tanzania respectively, that mass-media forms of communication (especially radio) were mostly relied upon for effective communication. The reliance on interpersonal channels shown here by rural fish farmers in Malaita Province demonstrates the need to recognize and appreciate locally appropriate sources and channels that can be useful for communicating small-scale tilapia aquaculture information. In this way, development interventions involving rural communities can not only build on or utilise these locally appropriate communication attributes for effective dissemination of information but importantly ensure its wider adoption. Nevertheless, the reliance on these locally appropriate communication channels alone may be inadequate for the longer-term sustainability of small-scale tilapia aquaculture by adopters. Technical assistance and extension services are equally vital to ensure the spread of sustainable SSA, because although relatives may be a go-to source for information, they may only hold basic awareness knowledge but not the 'knowledge of practice'. The latter is an important form of social capital for sustaining innovations like small-scale tilapia aquaculture over time and ensuring its tangible impact on livelihoods and food security (Blythe et al., 2017). Studies by Adesina et al. (2000); Baticados et al. (2014); Hudson et al. (2016); Ofuoku et al. (2008); Tenge et al. (2004) and Wetengere (2011) all support the need for extension services to farmers in promoting wider adoption and sustainability of innovations in both aquaculture and agriculture. The findings presented in this chapter also revealed that while small-scale tilapia aquaculture was less complex and compatible with the socio-cultural norms and livelihood demands of farmers, it had low relative advantage and observability. Although not established in the findings, these weaker attributes of small-scale tilapia aquaculture (i.e., low relative advantage and observability) may have contributed to adopters shifting to other economically viable activities after practising the activity for some time (Harohau et al., 2016). Addressing these weaker attributes of small-scale tilapia aquaculture can therefore be

vital to ensure the innovation has the potential for wider adoption and achieve overall success for the initiative.

2.6. Limitation

In this chapter, I identified several influential variables for small-scale tilapia aquaculture adoption in a rural Solomon Islands setting. The results presented in this chapter also provide several limitations worth highlighting. First, despite the classification tree model identifying socio-economic variables as most influential on small-scale tilapia aquaculture adoption, this does not necessarily suggest the other variables (communication channels and attributes of innovation) were unimportant. Rather, the outcome may be attributed to the nature of the classification tree analysis, which modelled the influences of the sets of independent variables on adoption based on the data's underlying distribution properties (Lo et al., 2015). Hence, the recursive partitioning of the variables into homogenous groups may mask the importance of other independent variables that would otherwise be relevant once considered alone (Loh, 2011). Second, although I was able to show some factors influencing small-scale tilapia aquaculture adoption, these factors may not cover all possible factors potentially influencing the activity's adoption in the local context. There may be other variables less related to the DOI theoretical framework that could be measured to observe their influence on small-scale tilapia aquaculture adoption (e.g., institutional factors). Future research can expand on this and look into other potential variables. Finally, data collected for this chapter occurred well after adoption decisions were made by farmers, hence, there may be potential limitations due to recall bias. As Meyer (2004) stated, farmers' ability to accurately recall past events may be limited and subjected to various biases. To address this potential limitation in future studies, data could be collected multiple times through longitudinal studies (Meyer, 2004).

2.7. Conclusion

In this chapter, I aimed to understand the factors influencing the adoption of small-scale tilapia aquaculture in a rural Solomon Islands context using the DOI theoretical framework. This chapter contributes to knowledge on SSA adoption, especially from a Pacific Islands regional context. The results suggested that socio-economic attributes were more influential than attributes of the innovation and communications channels on the adoption of small-scale tilapia aquaculture. Specifically, adopters tended to be older, male, less subsistence-oriented and with basic MSL. The analysis also showed that relatives and word-of-mouth were the most common forms of communication in the study context. While small-scale tilapia

aquaculture was compatible with socio-cultural norms and livelihood demands of farmers, it had a low relative advantage and observability.

The findings suggest that interventions pertaining to small-scale tilapia aquaculture development must prioritise understanding the socio-economic attributes of rural farmers and how these attributes influence adoption. This includes consideration of the issue of equity and the ability to adopt new innovations and the associated distribution of benefits. This is vital in identifying farmers' capacity to adopt and benefit from tilapia aquaculture, at the same time avoiding SSA interventions that run the risk of further marginalising certain groups in the community (e.g., women). The findings presented in this chapter also support the need to recognise locally appropriate channels of communicating for the effective dissemination of information.

Taken together, findings from this chapter suggest that for small-scale tilapia aquaculture to contribute to livelihoods and food security in Solomon Island, and across the Pacific Islands region, governments, development agencies, and non-governmental organisations will need to continue investing in research and programs that engage closely with local social dynamics that shape its adoption by rural households.

CHAPTER 2 SUMMARY: Social factors influencing adoption of small-scale tilapia aquaculture in rural Solomon Islands.

Across many PICTs, food insecurity and malnutrition are on the rise. In response, governments, development agencies, and non-governmental organisations are promoting small-scale aquaculture as a complement to fish supplied through coastal fisheries. While small-scale aquaculture has been widely adopted in parts of Asia and Africa, its adoption in rural Pacific Island communities remains relatively low. In this chapter, I draw on Diffusion of Innovation theory and apply a classification tree analysis to model the influence of farmers' socio-economic attributes, communication channels, and attributes of the innovation, on the adoption of small-scale tilapia aquaculture. I compare 40 tilapia aquaculture adopters with 40 non-adopters in Malaita Province, Solomon Islands. My results show that farmers' socio-economic attributes have the highest influence on small-scale tilapia aquaculture adoption. Tilapia aquaculture adopters were older, male, less subsistence-oriented, and had lower material styles of life than non-adopters. Information regarding small-scale tilapia aquaculture was most shared through informal channels, including relatives and word-of-mouth, compared to formal sources (e.g., fisheries extension officers, expert farmers, pamphlets, and posters). Lastly, while small-scale tilapia aquaculture was compatible with socio-cultural norms and livelihood demands, its relative advantage and observability in comparison with other livelihood activities were perceived as low. Overall, this chapter suggests that small-scale tilapia aquaculture, and its associated benefits, are not reaching the poorest and vulnerable groups (e.g., women or subsistence-oriented households) in rural Solomon Islands. These findings point to the need for an in-depth understanding of the socio-economic attributes of farmers to ensure strategies support marginalised groups to participate effectively in and tangibly benefit from small-scale tilapia aquaculture. The chapter also highlights the need to better utilise informal and locally appropriate communication channels to support the spread of small-scale tilapia aquaculture in rural Pacific Islands contexts. Ultimately, this research can inform small-scale aquaculture development policies of the Government of Solomon Islands, and other Pacific Island Countries, to support the sector in contributing to rural food and nutritional security.

3. Chapter 3: Contribution of small-scale tilapia aquaculture to livelihoods of rural farmers in Solomon Islands

3.1. Preface

Small-scale tilapia aquaculture – as an SSA initiative – is a newly introduced livelihood activity in Solomon Islands and, as I have established in chapter 2, its adoption among rural farmers is influenced by various factors. As a complementary livelihood activity, there is little empirical evidence on its contribution or impact on fish farmers' livelihoods. During my experience working with tilapia farmers, one pond management practice that was least adhered to was the regular harvesting of fish after every three months. This management practice among others was intended to assist tilapia farmers to improve their pond productivity over time, given the unfavourable biological attributes of the Mozambique tilapia currently farmed (Harohau et al., 2016). Though many fish farming households had access to tilapia ponds, they still dominantly bought marine fish from the market or go fishing themselves to sell their catch at the market, especially those fish farmers near the coast. These factors have influenced the extent to which fish farmers were utilising tilapia from their ponds for their household needs (e.g., food, income, etc.). In this chapter, I employ the Sustainable Livelihood Framework (SLF) to specifically explore small-scale tilapia aquaculture's contribution to fish farmers' assets and livelihood outcomes (e.g., income and food). A version of this chapter was published as: Harohau, D., Blythe, J., Sheaves, M., & Diedrich, A. (2020a). Limits of Tilapia Aquaculture for Rural Livelihoods in Solomon Islands. *Sustainability,* 12(11), 4592. https://www.mdpi.com/2071-1050/12/11/4592

3.2. Introduction

In the Pacific Islands region, like other developing regions globally, the growing pressure on coastal fisheries is leading to a decline in reef fish populations (Secretariat of the Pacific Community, 2008, 2013), though in some coastal areas coastal nocturnal pelagic fisheries may still be in a more favourable state (Roeger et al., 2016). Because reef fish provides most of the fish for rural communities and is a vital source of animal protein and key livelihood for many coastal communities, the decline has contributed to food insecurity and poverty (Bell et al., 2009). This translates into growing malnutrition in the rural contexts; particularly among vulnerable groups, such as pregnant women and children (Grieve et al., 2013; Susumu, 2014). Pervasive food insecurity and malnutrition have prompted governments, development

agencies and non-government organisations to explore SSA to support livelihoods and food security.

SSA often involves farming fish in simple earthen ponds that are low-cost, require minimal maintenance, and are usually family-operated (Edwards, 2000, 2013). In Asia and Africa, where most research on SSA has been conducted, SSA is widely practised by rural fish farmers as a livelihood activity that can contribute to their livelihoods, food security and rural development (Edwards, 2000; Halwart et al., 2003). As a complementary or supplementary fish production source, SSA has been shown to contribute to food security via three mechanisms: income, employment, and consumption (Ahmed & Lorica, 2002; Edwards, 2013; Kawarazuka & Béné, 2011). For most rural farmers with limited livelihood opportunities, SSA can become one of a diverse portfolio of livelihood activities given the right conditions exist (e.g., presence of extension services, right policies, markets, etc.) (Edwards, 2010). A substantial number of studies have demonstrated the positive contributions of SSA to the livelihoods of rural communities in developing countries (Ahmed & Waibel, 2019; Ahmed, 2009; Castine et al., 2017; E-Jahan et al., 2010; Farquhar et al., 2018; Nzevu et al., 2018; Pant et al., 2014).

As noted above, empirical evidence on the impact of SSA on rural livelihoods stems largely from research in Africa and Asia (Arthur et al., 2013; Béné et al., 2016), while research on the contributions of SSA in the Pacific Islands region remains relatively scarce. Overall, the potential contributions of SSA to rural livelihoods are highly contextual, where success stories in one context may not translate into other contexts in easily anticipated ways.

To better understand these contexts, this chapter investigates the contributions of small-scale tilapia aquaculture to rural livelihoods in Malaita Province of Solomon Islands. Specifically, I ask: to what extent is small-scale tilapia aquaculture contributing to livelihoods assets and outcomes in rural Solomon Islands? To answer this question, I utilise the SLF for my analysis (Chambers & Conway, 1992; Scoones, 1998). The information presented in this chapter also provides a basis from which policy and decision-makers concerned with small-scale tilapia aquaculture development can aim to improve the contribution of the sector and inform its direction towards achieving its expected role of improving livelihoods and food security.

3.2.1. An analytical framework for exploring the contributions of small-scale aquaculture to rural livelihoods in the Pacific Islands context

Sustainable livelihoods are characterised by two key concepts (Figure 4). First, livelihoods are defined as the capabilities, activities and assets needed to make a living (Chambers & Conway, 1992; Scoones, 1998). Second, a livelihood is considered sustainable when it can cope with, and recover from, stress or shocks without jeopardising the resource base (ibid). The SLF is an analytical framework that provides a heuristic for examining the interacting components that influence livelihoods in rural communities.

The framework helps to identify the connections between people and their enabling environment, which inevitably influence their livelihood strategies and outcomes.

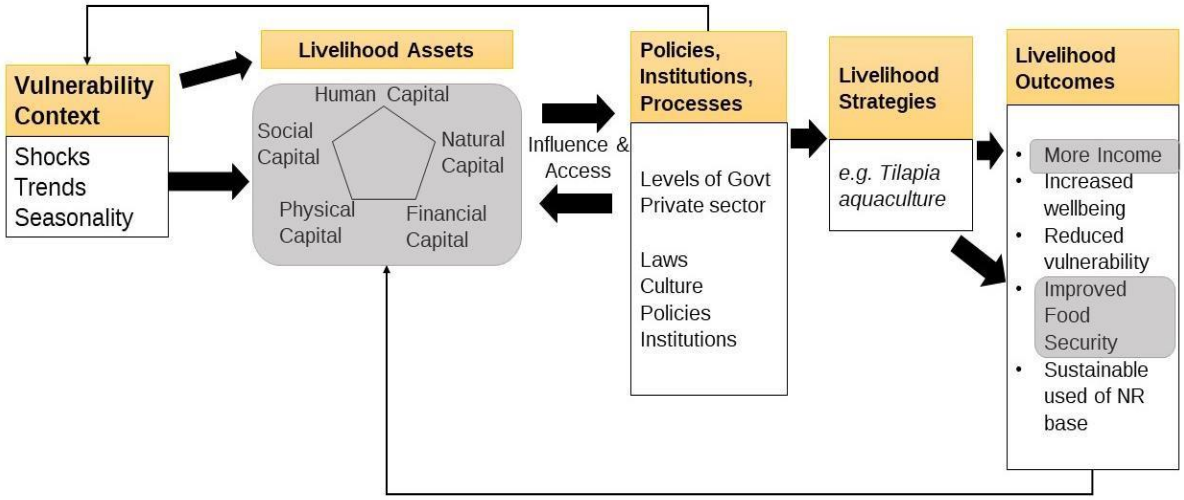


Figure 4: Components of the sustainable livelihood framework. Note: Boxes shaded grey (livelihood assets and outcomes) were those used to analyse the impact of small-scale tilapia aquaculture on rural livelihoods presented in this chapter. This figure was modified from Scoones (1998).

Central to the SLF is the notion of the five livelihood assets (i.e., human, natural, social, physical, and financial). Assets are defined as the resources people require to pursue their livelihood strategies (Scoones, 1998; Solesbury, 2003). Vulnerability contexts and policies, institutions, and processes, such as governance and policy norms, are understood to influence and mediate access to livelihood assets. People often employ a range of livelihood strategies (e.g., adoption of aquaculture) to achieve desired livelihood goals. Livelihood outcomes, such as food security and income are often shaped by the interactions among these different components of the SLF which can also introduce feedback and influence livelihood assets. In this chapter, two key components of the SLF are explored to determine the contributions of small-scale tilapia aquaculture to rural livelihoods in Solomon Islands. These are livelihood

assets and livelihood outcomes.

3.3. Methods

3.3.1. The context of small-scale tilapia aquaculture in Solomon Islands

Currently, Mozambique tilapia is the only tilapia species found in Solomon Islands waterways. The species was introduced into the country in the 1950s and 1960s to control mosquito populations and to enhance local fish stocks (Eldredge & Humphries, 1994; Ponia, 2003). Due to its hardiness and invasive nature, tilapia has spread into most water systems around the country and established itself among the endemic flora and fauna. According to the International Union for Conservation of Nature, Mozambique tilapia is considered an invasive species so, in some PICTs, efforts are underway to completely eradicate it from their waters (Nico & Walsh, 2011). Yet, in some rural communities of the larger provinces of Solomon Islands, where the species has established itself (e.g., Lees Lake on Guadalcanal and Lake Tegano on Renbel Province), Mozambique tilapia forms an important part of local diets in communities where access to marine fish is limited (Schwarz et al., 2013).

Mozambique tilapia aquaculture is one of the most recent developments in the history of aquaculture development in Solomon Islands (see Table 3). Its domestication coincided with the national government's recognition that the country was facing declines in its coastal fisheries production as a result of the increased human population, unsustainable fishing, agricultural and coastal developments and climate change (Asian Development Bank, 2014). Declining coastal fisheries production, and the anticipated shortfall of marine fish, motivated the government, with assistance from development agencies, to begin exploring the potential of Mozambique tilapia for aquaculture in various places throughout the country (Asian Development Bank, 2014; Ministry of Fisheries and Marine Resources, 2010; Weeratunge et al., 2011).

Table 3: History of aquaculture development in Solomon Islands from the 1960s–2018.

Year	Aquaculture Development
1950–60	Pearl oyster aquaculture in Wagina (Choiseul Province)
1980s	*Macrobrachium rosenbergii* aquaculture started on West Guadalcanal. International Centre of Living Aquatic Resource Management (ICLARM) (now WorldFish) research station was established, and seaweed aquaculture was introduced into Solomon Islands
1990s	Shrimp aquaculture was established on Guadalcanal. Pearl aquaculture was encouraged in parts of Kia (Isabel Province) and Wagina (Choiseul Province)

2000–2008	An aquaculture division was established in the Ministry of Fisheries and Marine Resources. In Gizo (Western Province) a clam hatchery was developed, with coral farming, commercialization of seaweeds and pearl aquaculture explored.
2009–2018	Tilapia initiatives (*O. mossambicus*) commenced, with the government establishing a community aquaculture program. Seaweed aquaculture was expanded to other provinces. The potential of *P. monodon* was investigated. The National Aquaculture Policy was formulated.

Sourced from Solomon Islands Ministry of Fisheries and Marine Resources (2019)

3.3.2. Participants Selection and Data Collection

Purposive sampling which was used to identify participants in Chapter 2 was also used to identify interviewees, though, for this sampling, only tilapia farmers were approached (Harohau et al., 2016). This connection was established from my previous experience working as an extension officer with most of the tilapia farmers in the study site. A total of 58 tilapia farmers were identified by Harohau et al. (2016) to have practiced small-scale tilapia aquaculture in the study area. Of these, 40 tilapia farmers were interviewed: representing an estimated 69% of all active tilapia farmers in the study area.

Before conducting fieldwork, interview schedules and logistics were organised via mobile phone and word of mouth as these are the common modes of communication in Malaita Province and Solomon Islands in general. Interviews were again conducted with the help of a trained field assistant who was both well versed with the local socio-cultural context. Interviews were conducted in pidgin and transcribed into English for later analysis.

The data presented in this chapter was collected over two time periods with the same group of respondents. In the initial data collection in 2017, individual face-to-face interviews with tilapia farmers focused on understanding small-scale tilapia aquaculture's contribution to their assets and livelihood. In the second round of data collection in 2018, household-level interviews were conducted to record household food consumption using 24-hours and seven-days ASF recall methods (Swindale & Bilinsky, 2006). Interviews were carried out at a time and location preferable to the respondents. Table 4 shows the list of variables used for this study.

Table 4: Study variables.

Component of Sustainable Livelihoods Framework *	Variables	Measurement Scale/Component Calculation
Livelihood assets		
Human assets include the knowledge, skills, labour, and good health necessary to engage in diverse livelihood strategies.	▪ Satisfaction with tilapia aquaculture's contribution to skills and knowledge on fish farming. ▪ Satisfaction with tilapia aquaculture's contribution to household food consumption.	Likert scale (0-10) "Human assets" = mean of both scales
Financial assets are savings, credits and debts needed to achieve livelihood goals.	▪ Satisfaction with the income generated from tilapia aquaculture.	Likert scale (0–10)
Social assets are social resources (social network, trust, connectedness) people drawn upon in pursuit of their livelihood goals.	▪ Satisfaction with tilapia aquaculture's contribution to social network (e.g., expand current network).	Likert scale (0–10)
Physical assets are the infrastructures (e.g., roads, tools, etc.) and goods required to support livelihoods.	▪ Satisfaction with the tools and equipment available as a result of tilapia aquaculture.	Likert scale (0–10)
Natural assets include intangible assets (e.g., air, nutrient cycle) and tangible ones (e.g., water, trees, land).	▪ Contribution of tilapia aquaculture to natural assets (e.g., tilapia for fish meal or pond water utilized for other purposes).	Coded qualitative & binary
Livelihood outcomes		
Food security	▪ Frequency of tilapia consumption per year ▪ 24-h & 7-days recall of food and meat consumption by households (kg)	Scale
Income	▪ If tilapia farmers sold their tilapia or not ▪ How much income was obtained from tilapia sold?	Binary Scale

* Definitions of the SLF components were sourced from Scoones (1998).

3.3.3. Data Analysis

Descriptive statistics were used to interpret the quantitative data. Inductive coding was conducted on qualitative responses to identify common emergent themes. In some instances, re-occurring themes were weighted according to their frequencies across the sample size and then presented graphically. Data analysis was performed using Microsoft Excel.

3.4. Results

3.4.1. Small-scale tilapia aquaculture's contribution to livelihood assets

The Likert scores indicated that the largest proportion (>50%) of tilapia farmers were satisfied with the contribution of small-scale tilapia aquaculture to their human assets (Figure 5). Farmers valued the activity's contribution to their knowledge and skills of fish farming, and also to household food consumption (though this contrasts with the fact that only two households consumed tilapia in the last seven days; see tilapia aquaculture's contribution to livelihood outcome on page 5 of this thesis). This included 20% and 23% of tilapia farmers who were "strongly satisfied" with the activity's contribution to their knowledge and skills, and household food, respectively. Similarly, 53% were also satisfied with the expansion of their social connections and network due to tilapia aquaculture. A relatively high proportion of these tilapia farmers (20%) were "strongly satisfied" with the activity's role in the expansion of their existing social assets. In contrast, 40% of tilapia farmers were dissatisfied with small-scale tilapia aquaculture's contribution to financial assets, of which 28% were "strongly dissatisfied". For physical assets, farmers reported equal levels of satisfaction and dissatisfaction (both 28%) with the activity's contribution to their physical assets.

The contribution of small-scale tilapia aquaculture to natural assets was recorded qualitatively. Farmers were asked what other purposes tilapia aquaculture has served their households (e.g., if pond water was used for livestock/vegetable gardens or tilapia was used as supplementary fish meal for piggery, etc.). For most farmers (40%), small-scale tilapia aquaculture did not serve any other purposes, while 26% explained that farming tilapia only contributed towards food consumption – which was minimal.

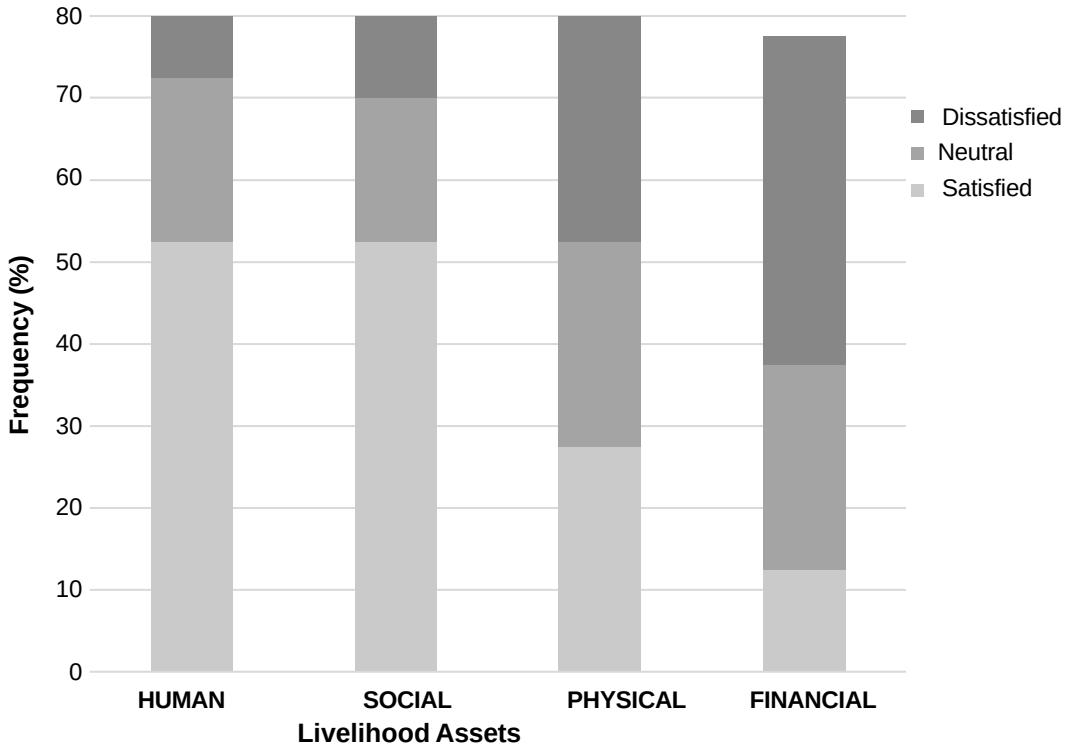


Figure 5: Tilapia farmer's level of satisfaction with small-scale tilapia aquaculture's contribution to their livelihood assets. Tilapia farmers, in general, had high levels of satisfaction with small-scale tilapia aquaculture's contribution to their social and human assets. The highest level of dissatisfaction was with the activity's contribution to financial assets.

3.4.2. Small-scale tilapia aquaculture's contribution to livelihood outcomes

Small-scale tilapia aquaculture contributed minimally to household food consumption in the study area. Almost half (43%) of respondents indicated that tilapia was only consumed once a year. Seventy-eight percent of the farmers that consumed tilapia annually, indicated that they consumed all the fish they harvested – implying that no harvested tilapia was shared among others.

Figure 6: Tilapia from small-scale tilapia aquaculture contributed minimally to household food consumption in rural Malaita Province, Solomon Islands. Photo credit: WorldFish, 2015.

The minimal contribution of tilapia to household food security was validated in follow-up household interviews that employed the 24-hours and seven-day ASF consumption recall methods. These interviews showed only two households had consumed tilapia in the previous seven-days and none had consumed tilapia in the last 24-hours. These two households consumed an estimated 0.014kg and 0.210 kg of tilapia, respectively. For household A, this contribution of tilapia accounted for 0.3% of the combined weight (kg) of all fish types (pelagic fish, reef fish, canned sardine, canned mackerel, canned tuna and freshwater fish) consumed in the past seven-days. For household B, tilapia was the only fish consumed in the last seven-days.

Small-scale tilapia aquaculture also contributed negligibly toward household income. In fact, only 20% of all tilapia farmers had sold their tilapia for income within the previous year. The weekly income of these farmers ranged from SBD325.56 (USD40.78)[7] to SBD8,925.19 (USD1,117.88). Of this weekly income, small-scale tilapia aquaculture contributed only 0.002% to 0.5% of total income earned per week. The three most common reasons for not selling tilapia as expressed by farmers were: (1) tilapia was only for food at this stage, (2) tilapia was too small for sale, and (3) lack of consumer demand for tilapia.

[7] Exchange rates indicated are calculated from https://www.xe.com/currencyconverter/ on 15th of May 2021.

3.5. Discussion

Coastal reef fisheries are declining in many areas of the Pacific Islands region (Secretariat of the Pacific Community, 2008, 2013). Given this context, SSA has been proposed by governments, development agencies and non-government agencies as a complementary fish production source (Bell et al., 2009; Secretariat of the Pacific Community, 2013). However, there is limited conclusive evidence about the contribution of small-scale tilapia aquaculture to rural Pacific Islands communities. Through interviews with 40 tilapia farmers in Malaita Province, the results presented in this chapter have shown that just over half (>50%) of all tilapia farmers interviewed were satisfied with small-scale tilapia aquaculture's contribution to their human and social assets. Tilapia's contribution towards financial, physical, and natural assets were also limited.

Overall, small-scale tilapia aquaculture is not contributing significantly to livelihoods or food security for rural tilapia farmers in Malaita Province. These findings contradict dominant narratives about the benefits of SSA on rural livelihoods mostly from Asia and Africa, where SSA has been found to perform better and contributing to rural livelihoods and food security (Abdullah et al., 2016; Ahmed & Waibel, 2019; Ahmed, 2009; Ahmed & Toufique, 2015; Duc, 2009; Kumaran et al., 2020; Palanca-Tan, 2018; Villasante et al., 2015). The limited contribution of small-scale tilapia aquaculture to livelihoods and food security in Malaita Province is a result of two contextual aspects. First, the SSA sector in Solomon Islands lacks a tilapia species that is well suited for SSA production. Second, local demand for tilapia in domestic markets is low.

The attributes of early reproduction, stunted growth and high fecundity render Mozambique tilapia an unsuitable species for SSA that aims to contribute to livelihoods, food security and rural development (Pickering, 2010). In fact, the species has been referred to as a "wrong species" for SSA in the Pacific Islands region due to its biological and ecological attributes (Pickering, 2010; Ponia, 2010). This presents a problem when fish farmers' motivations for adopting aquaculture are usually to diversify their livelihoods and increase food security (Ahmed & Lorica, 2002; Edwards, 2000; Halwart et al., 2003). The unattractive traits of the Mozambique tilapia for SSA have prompted other PICTs, particularly Papua New Guinea, Fiji and Vanuatu to shift their attention to farming better performing species like Nile tilapia and the Genetically Improved Farmed Tilapia (GIFT) (Amos et al., 2014; McKinna et al., 2010; Nandlal & Foscarini, 1990; Smith, 2007). In Solomon Islands, this potential of

obtaining a better performing tilapia species in aquaculture should be prioritised if the sector is to improve from its current production status and play a significant role in supporting livelihoods and increasing food security (Sulu et al., 2015a). A study of small-scale fish farming in Zambia by Kaminski et al. (2019) also highlighted that rural farmers still struggle to optimize benefits obtained from their fish farming because of difficulty accessing quality inputs (e.g., in the form of quality fingerlings and feed) (Hasimuna et al., 2019).

The development of the small-scale tilapia aquaculture sector in Solomon Islands is also constrained by the lack of demand for tilapia in domestic markets. This study found that Mozambique tilapia does not possess much monetary value, as a consequence of poor consumer demand. Two reasons are responsible for this poor demand for tilapia among consumers: (1) a current market for tilapia does not exist in Solomon Islands (also evident across most PICTs), and (2) tilapia is relatively new to most contexts in the Pacific Islands region and will take time before it might compete with marine fish at domestic markets, despite being promoted for a number of decades now (Cleasby et al., 2014). These factors, in essence, are limiting the activity's potential and long-term sustainability among rural tilapia farmers and restricting its contribution to food and income security (Adams et al., 2001; Edwards, 2000). The limited local experience with and demand for farmed fish species, nevertheless, is a challenge for the Pacific Islands region and has been identified as an area for support and investment in the coming years (Amos et al., 2014). As Edwards (2000) highlighted, the maximum impacts of SSA for rural livelihoods are only possible if fish farmers have a market for their products (Ahmed & Lorica, 2002; Ahmed, 2009; Ahmed & Toufique, 2015; Ahmed et al., 2012; Khondker et al., 2018; Margaret & Gakuu, 2018).

Since the current Mozambique tilapia aquaculture has shown little impact on livelihoods and food security, coastal fisheries will still play the leading role in supplying fish for consumption and income generation in rural communities in Solomon Islands – as evident through the intensifying demand for coastal fisheries resources (Albert et al., 2015; Molea & Vuki, 2008; Rabbitt et al., 2019; Roeger et al., 2016; Sulu et al., 2015b). For instance, women in the Western Province of Solomon Islands who used to glean in the coastal tidal flats for shells and invertebrates have now moved offshore to fishing grounds previously dominated by men (Rabbitt et al., 2019). Local fishers have increasingly diversified their target species using various harvest methods in an effort to maximise catches (Albert et al., 2015). These trends suggest that coastal fisheries will continue to play a key role in supplying fish thus supporting

local livelihoods and food security (Cohen et al., 2019). This situation raises important questions that need to be addressed in the Solomon Islands and other PICTs such as: (1) is an investment in small-scale tilapia aquaculture a reasonable choice? (2) should efforts be diverted to developing other potential commodities for SSA (e.g., seaweed), or sea ranching instead (e.g., sea cucumber)? and (3) would it be more profitable to focus on improved management of wild fisheries, or alternative livelihoods and food security solutions? Addressing these questions can ensure, if it is deemed to be viable, meaningful progress towards improving current outcomes of small-scale tilapia aquaculture.

Finally, this study has also shown that Mozambique tilapia aquaculture is only contributing to social and human assets. Several studies have supported SSA's contribution to fish farmers' social and human capital (Ahmed et al., 2008a; Diedrich et al., 2018; Farquhar et al., 2018; Murshed-E-Jahan & Pemsl, 2011). Yet, other studies have demonstrated that fish farmers with limited social capital are unable to benefit from SSA (Ahmed, 2009; Fly, 2016). The contribution of SSA to human and social assets demonstrated in this study may be explained by the "newness" of the innovation among rural farmers in the local context. This may have prompted fish farmers to create new social connections and expand their existing social networks to maximise learning about small-scale tilapia aquaculture. The perceived contribution of small-scale tilapia aquaculture to social and human assets presented in this chapter are essential for the uptake of new innovations in participating communities, the long-term sustainability of the activity, and for promoting the innovation and ensuring farmers can tangibly benefit from SSA (Diedrich et al., 2019; Salazar et al., 2018). Too often the expectation is that such new innovations; externally motivated and introduced into rural communities as supplementary livelihoods must have an immediate impact on rural livelihoods. Yet, this has not been the case as far as livelihood projects – externally initiated – in the Pacific Islands are concerned. Experiences in the past have shown that most livelihood projects failed to exhibit immediate impact on target recipients because initiating institutions failed to take into account the diverse yet complex social, cultural, and economic context of Pacific Islands communities when designing projects (Eriksson et al., 2020; Gillett et al., 2008; Veitayaki, 2000). This has been obvious through the lack of ensuring community participation – where recipients can be able to determine and prioritise their development and livelihood needs – in the design phase of the projects (Govan, 2011). This often results in livelihood projects with minimal tangible impact and long-term sustainability issues, due to the mismatch between project (institution and donor) requirements and community needs

(Eriksson et al., 2020; Govan, 2011; O'Garra, 2007; Veitayaki, 2000). Other studies on SSA have also shown that acquiring appropriate knowledge and skills of fish farming is also vital for its adoption and success (Mulokozi et al., 2020; Sheheli et al., 2014). Therefore, policymakers, extension officers and project officers must ensure practical short and long-term support is put in place for rural tilapia farmers, especially during the early phase of introducing an innovation.

3.6. Limitation

This chapter provides important empirical evidence to counter narratives about the universal benefits of SSA for rural livelihoods, especially from a Pacific Islands perspective. However, several limitations are worth highlighting here. First, this chapter presents findings from a cross-sectional study conducted over approximately five years after several community members took up small-scale tilapia aquaculture. Hence, benefits arising immediately or after a longer implementation time would therefore not have been captured by this study. In the future, longer-term studies of the impacts of small-scale tilapia aquaculture may be useful to understand the benefits that may have accrued over time. Secondly, obtaining detailed and accurate information on tilapia consumption was a challenge, especially through the use of diaries and recalls on the estimated number and weight of tilapia consumed. This may be indicative of the irregularity of tilapia harvesting and consumption by farmers making it difficult for farmers to provide such vital information. Again, longer-term studies may be useful to capture detailed and accurate information on tilapia consumption rates.

3.7. Conclusion

This chapter addressed the question: *to what extent is small-scale tilapia aquaculture contributing to rural livelihoods in the Solomon Islands?* Results presented in the chapter have shown that over half of the tilapia farmers interviewed were satisfied with small-scale tilapia aquaculture's contribution to their human and social assets, yet the majority were dissatisfied with its contribution to physical and financial assets. Small-scale tilapia aquaculture's contribution to farmer's natural assets was also limited. Importantly, SSA contributed insignificantly to livelihoods and food security. Findings also suggest that farming the current Mozambique tilapia species is unable to contribute to livelihoods and food security and provide a meaningfully complement to coastal fisheries production.

Based on the findings presented in this chapter, the following recommendations are made. First, the government and relevant stakeholders must prioritise the introduction of a better performing tilapia species to replace the current Mozambique tilapia. As noted, Mozambique tilapia lacks the traits suitable for aquaculture. The Solomon Islands government has been considering the introduction of Nile tilapia for the last decade, however, it was only recently that concrete steps were taken towards this (e.g., the recent completion of the tilapia hatchery facility in west Guadalcanal) (Ministry of Fisheries and Marine Resources, 2010, 2018). Once the Nile tilapia is introduced into the country, then existing fish farmers should be involved in farming trails, given their experience with Mozambique tilapia.

Secondly, governments and other relevant stakeholders will need to increase their support for small-scale tilapia aquaculture to ensure the appropriate level of uptake and sustainability of the sector going forward. Factors such as lack of effective government extension services and delivery, and the importance of fish farmers' social networks for learning about the activity emphasise the need for continuous institutional support to nurture the growth of the sector (Blythe et al., 2017; Govan, 2011). This can be achieved through short and long-term support for rural tilapia farmers especially during the experimentation phase, whereby farmers are trialling small-scale tilapia aquaculture and making important decisions that will impact their livelihood strategies.

For policymakers and decision-makers concerned with small-scale tilapia aquaculture development for livelihood and food security in the Pacific Islands region, vital questions remained to be answered. These include but are not limited to: (1) is investment in small-scale tilapia aquaculture a reasonable choice? (2) should efforts be diverted to developing other potential commodities (e.g., seaweed) for SSA instead? and (3) would it be more profitable to focus on improved management of wild fisheries, or alternative livelihoods and food security solutions? Future research that explores these questions, can generate empirical evidence of whether SSA (tilapia aquaculture, or other alternate SSA livelihood activities) might meaningfully complement coastal fisheries production.

CHAPTER 3 SUMMARY: Contribution of small-scale tilapia aquaculture to livelihoods of rural farmers in Solomon Islands

Increasing pressure on coastal fisheries poses serious threats to local livelihoods and the food security of Pacific Islanders. In response, governments and development agencies have explored small-scale tilapia aquaculture as a complementary fish production source. Yet, evidence to date on the impact of small-scale tilapia aquaculture on rural livelihoods has been inconclusive. Drawing on the sustainable livelihood framework, I analysed the contribution of small-scale tilapia aquaculture – based on the Mozambique tilapia species – to the livelihood assets and outcomes of 40 rural farmers in Solomon Islands. First, results showed that 53% of tilapia farmers were satisfied with small-scale tilapia aquaculture's contribution to their human and social assets, while only 28% and 13% were satisfied with its contribution to their physical and financial assets, respectively. Small-scale tilapia aquaculture's contribution to farmers' natural assets was also limited. Second, and most importantly, there was an insignificant contribution of small-scale tilapia aquaculture to food and income security. The results demonstrate that tilapia farmers rarely consumed tilapia, with only two of the 40 households having consumed tilapia in the seven days before the interview. Moreover, only eight tilapia farmers sold their tilapia, which contributed 0.002–0.5% of their total weekly revenue. I argue the limited contribution of small-scale tilapia aquaculture to food and income stems from the low productivity of the available tilapia species and the low local demand for tilapia at rural markets. Given the current context of declining coastal fisheries and food insecurity concerns in rural Pacific Islands, it is unlikely that the current form of small-scale Mozambique tilapia aquaculture will be able to achieve its objective of addressing food and income security as a complement to coastal fisheries.

4. Chapter 4: Contribution of tilapia relative to other animal-sourced foods, in household diets

4.1. Preface

This chapter focuses on the contribution of farmed tilapia to household food security. Grivetti (2019, p. 24) states, *"...aquaculture scientists are faced with a situation. On one hand, success can be measured in terms of profit/economic return (i.e., livelihood outcomes) through local sales. But for such intervention to be successful, the product raised must be consumed by specific groups".* In the Pacific Islands region, this is the intention of most small-scale tilapia aquaculture initiatives, given current coastal fisheries production alone will unlikely meet fish demand by Pacific Islanders by 2030 (Secretariat of the Pacific Community, 2008). In this chapter, the current contribution of small-scale tilapia aquaculture to household diets is presented compared against other ASFs. A version of this chapter is currently prepared for submission to the *Aquaculture research* journal.

4.2. Introduction

In the Pacific Islands region, a triple burden of malnutrition exists in the form of over-nutrition, under-nutrition, and micronutrient deficiencies (Aldwell et al., 2018; Hughes & Lawrence, 2005; Hughes & Marks, 2010; Snowdon et al., 2013). This triple burden of malnutrition has been accelerated by a shift from consumption of locally sourced, low-calorie, nutrient-dense foods towards diets dominated by processed, high-calorie, low-nutrient content foods (Aldwell et al., 2018; Farmery et al., 2020; Haddad et al., 2014; Snowdon et al., 2013). The health consequence is an increased prevalence of malnutrition leading to increased non-communicable diseases amongst Pacific Islanders (Hughes & Marks, 2010). PICTs host nearly half of the global population currently experiencing multiple forms of malnutrition (Haddad et al., 2014). In Papua New Guinea and Solomon Islands, for example, ≥40% of children under five years old are stunted – i.e., low height for age (Akombi et al., 2017) – (Haddad et al., 2014). In Fiji, Solomon Islands, Nauru, and Western Samoa, >40% of pregnant women are anemic, a condition often attributed to diets low in iron (Grieve et al., 2013). Severe micronutrient deficiencies can lead to the delayed physical and cognitive development of children that affects their ability to perform at school, have lifelong effects on intellectual capacity, and leads to vulnerability to diseases, blindness, higher rates of illness and mortality among affected children (World Health Organization, 2010). The impacts of malnutrition fall not only on individuals but have broader societal and economic costs that add pressure to the

already under-resourced health services typical of countries in the Pacific Islands region (Hughes & Marks, 2010).

Fresh fish is a rich source of micronutrients, essential fatty acids, and high-quality protein (Hicks et al., 2019; Roos et al., 2007). A recent study by Hicks et al. (2019) found that tropical pelagic fish are a rich source of micronutrients such as calcium, zinc and iron, which are essential for human development and health. Smaller pelagic tropical fish, on the other hand, have higher concentrations of zinc and omega-3 fatty acids, which are essential for optimal mental health and functioning (Richardson, 2003). This variation between tropical and pelagic fish species can have implications for diet quality when considering transitions from capture fishery dominated systems to culture dominated systems – even if volumes of fish consumed remain constant (Bogard et al., 2016; Hicks et al., 2019). However, irrespective of the variability in nutrient content, the micronutrients present in fish are linked to various health benefits, like reduction of cardiovascular diseases, diabetes, some forms of cancer, reduction in chronic inflammation, weight control and blood pressure, but also infant development, mental health and cognitive development (Lund, 2013).

On average, Pacific Islanders consume between 18 – 63kg of fish/capita/year – which is almost double the recommended animal protein consumption by the World Health Organisation (35kg/capita/year) (Bell et al., 2009; Charlton et al., 2016). These averages demonstrate that fish dominantly supplied by coastal fisheries, with some contribution from aquaculture, is consumed at high rates in PICTs (Bell et al., 2009). Recent research highlights that the consumption of fresh fish is heterogeneous and may not be sufficient to meet the nutritional needs of all groups within the society across all locations (Albert et al., 2020). Fish supply-demand projections suggest that by 2030, PICTs will need an additional 115,000 tons of fish to meet future fish supply-demand needs if current fish utilisation remains unchanged (Bell et al., 2009; Secretariat of the Pacific Community, 2008). To ensure continuity of fish supply that is in line with local preferences, livelihoods and cultures, effective management strategies for coastal fisheries is required (Cohen et al., 2015; Cohen & Foale, 2013). A range of additional strategies are also proposed to ensure fish production meets demand. These include the use of inshore fish aggregating devices to increase access to pelagic species (Albert et al., 2014; Bell et al., 2015a), the utilisation of offshore tuna fisheries to better supply domestic rather than just international markets (Bell et al., 2015b), the promotion of convenient fish products like canned fish (Bell et al., 2019), and SSA to produce food fish

(Adams et al., 2001; Amos et al., 2014; Ponia, 2010)(Adams et al., 2001; Amos et al., 2014; Ponia, 2010).

This chapter focuses on small-scale tilapia aquaculture as a potential complement to coastal fisheries in Solomon Islands (Amos et al., 2014; Pickering, 2010). While small-scale tilapia aquaculture has been proposed as a potential strategy to mitigate a projected shortfall in future fish supply, it is vital to understand the extent to which farmed tilapia actually contribute to local diets relative to the role of coastal wild capture fisheries and other sources of fish. This will help understand the contexts in which small-scale tilapia aquaculture has, if any, substantial potential to provide positive impacts. To date, investments in small-scale tilapia aquaculture in the Pacific Islands region are still based largely on the assumption that increasing production of the species will lead to increased food security. However, there is limited empirical evidence to demonstrate the contribution of small-scale tilapia aquaculture to livelihoods, food security, rural development and overall improvements in the wellbeing of Pacific Islanders (see Chapter 3).

This chapter aims to address this information gap by considering the case of small-scale tilapia aquaculture – based on the Mozambique tilapia species – in Solomon Islands and its contribution to household diets, relative to coastal fisheries and other types of ASF consumed. Three research questions inform this chapter: 1) What is the composition and diversity of household diets in rural communities in Solomon Islands? 2) To what extent are fresh marine fish, processed fish products, freshwater species, and farmed tilapia contributing to ASF consumption?; and 3) How do fish consumption vary with distance to coasts and distance to markets? To answer these questions, data were collected from 68 households across six farmer clusters. From the findings, I discuss the opportunities and limits for small-scale tilapia aquaculture as a supplementary food source, particularly in Malaita Province of Solomon Islands.

4.3. Materials and methods

4.3.1. Study site

Data presented in this chapter was obtained during my second fieldtrip in 2018. In addition, local markets identified by the households where they frequently purchased their food (including fish) were also recorded (Figure 7).

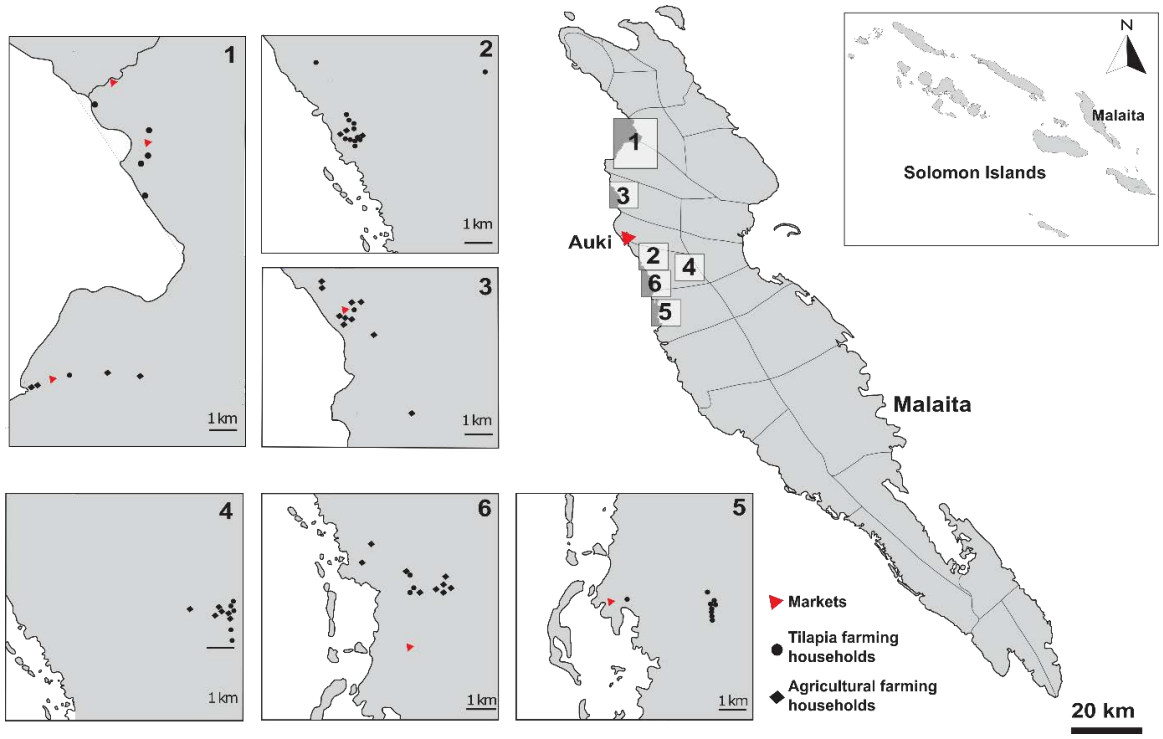


Figure 7: Map showing the location of interviewed households and markets across the six farmer clusters in Malaita Province, Solomon Islands. The households are located across six farmer clusters situated on the north, south, and south-east side of Auki – the administrative and central business district of Malaita Province.

4.3.2. Participant selection

The same participants from my initial fieldwork were visited again in this second round of fieldwork; except, in this round, I considered the household as my unit of interest as opposed to individual farmers. Participating households were represented by consenting household heads (i.e., the farmer and/or their spouse). However, because some households were absent during my visit, only 68 households were interviewed representing 36 tilapia farming and 32 non-tilapia farming households, instead of an initial 80 households.

Twelve focus groups consisting of six groups of women and six groups of men were also conducted to support and validate household food consumption data across the different seasons. In all interviews and consultations, a consent form was provided to participants; however, because most rural villagers could not read, their oral consent was obtained.

4.3.3. Data collection

Data for this chapter were collected via semi-structured household interviews and focus group discussions between November 5th and December 5th, 2018. The semi-structured interviews

were designed to collect data on the types of food consumed by households in the last 24-hours (24-hour food recall), the types of ASF consumed by households in the last seven-days (seven-day recall) and the types of food consumed across different seasons (seasonal food recall). Interviews were held with both the male and female household heads, with other household members participating when possible. Interview questions were guided by the *Guidelines for measuring household and individual dietary diversity* (Swindale & Bilinsky, 2006). For the 24-hour food recall, respondents were asked to list the foods consumed within their households in the last 24-hours, whether in the home or outside the home including probes for frequently forgotten and/or hidden foods (e.g., fruit and nuts consumed whilst tending to agricultural plots, rather than as part of a meal). To aid with recalling types of ASF consumed in the previous seven-days, households were shown 19 cards with pictures of different ASF types (Mathews et al., 2018). When fish (marine, freshwater species, and tilapia) was mentioned, respondents were further probed to estimate the fish lengths. Respondents were probed on length of fish instead of weight because in the local context (especially in the rural areas) anything to do with the metric system of measurement (e.g., length, volume or weight), people are inclined to use lengths rather than weights. To aid respondents, a board calibrated from 0cm to 90cm using a metre ruler was used to estimate fish lengths. I later converted these measurements to weights (see Section 4.3.4). For processed fish products, respondents were asked to recall the size of the products; either a small, medium or large-sized can, and the specific processed fish product (e.g., canned tuna, mackerel or sardine). The actual weights of the canned fish products were later obtained at the office.

Because of the limited ability of the 24-hours and seven-days recall methods to account for foods that may be consumed in different seasons (Genschick et al., 2018; Kennedy et al., 2011; Swindale & Bilinsky, 2006), households were questioned about the food items they consumed across the different seasons. Information to support the interpretation of the household seasonal food recall (e.g., how many seasons, when etc.) was validated by discussions held with the 12 focus groups (described above) – which lasted up to two hours.

Coordinates of household dwellings were taken with a Garmin eTrex30 GPS to calculate distances to identified market locations and also the distance to the coast.

4.3.4. Data Analysis

Before quantitative data analysis was conducted, relevant conversion of the collected data was performed. Firstly, because it was impractical to obtain the weight of fish consumed by households, only lengths (cm). These lengths were then used to estimate the weight of the fish using length and weight measurements from a WorldFish unpublished fish survey data from Auki Fish Market (Sulu et al., 2018). This was done following protocols stipulated by the WorldFish guide for measuring fish consumption by estimating fish portions (Bogard et al., 2017b).

For freshwater species, because there were no available and accessible data for Solomon Islands, respective weights (kg) were estimated from available literature on the specific species (mostly from the Pacific Islands region). Apart from Jungle perch (*Kuhlia rupestris* and *Kuhlia marginate*), freshwater species in this case also included freshwater prawn (*Macrobrachium lar*) and eel (*Anguilla bicolor*). Weight measurements of these freshwater species were estimated using work by Barbier et al. (2010); Batty (1987); Hoskin et al. (2015) and Polhemus et al. (2008).

For the foods consumed in the last 24-hours and seasonal food items mentioned by households, the *Guidelines for measuring household and individual dietary diversity* (Swindale & Bilinsky, 2006) was used to group the food items into 12 food groups. The 12 food groups indicated the dietary diversity in terms of the number of different food groups households consumed, rather than the number of different foods consumed (ibid). The 12 food groups were: a) cereals; b) roots and tubers; c) vegetables; d) fruits; e) meat, poultry, offal; f) eggs, g) fish and seafood; h) pulses/legumes/nuts; i) milk and milk products; j) oils and fats; k) sugar and honey, and l) miscellaneous (foods that do not fit into the aforementioned food groups). Household dietary diversity was obtained by summing the number of food groups consumed in the last 24-hrs and across seasons. A score of "1" was assigned if a food item in the 12 groups were mentioned, while "0" was assigned to food groups not consumed. The household dietary diversity score used in the result was the mean of individual dietary diversity scores of the 68 households.

Statistical Package for the Social Sciences (SPSS) – IBM version 26 - was used to perform descriptive statistics. Correlation and bivariate functions were also used in SPSS to obtain the correlation matrix between fish consumption and distances of households to coast and

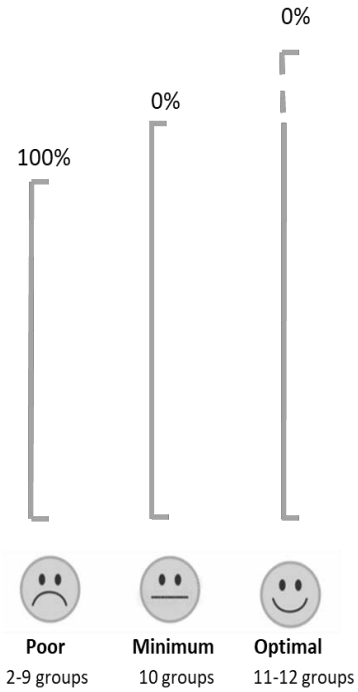
markets. Microsoft Excel was used to plot graphs to visually represent reported results. Distance to the coast and the usual markets were estimated using the Google Earth Pro ruler feature, an approach used by Goudie (2013) to measure salt marsh morphologies. This was done by inserting GPS coordinates of households and the markets into the software and using the ruler feature to draw a straight line to the coast and market to estimate the length (km). This function within Google Earth gave both a map length (straight-line) estimate between two points on the map, as well as an on-ground distance in kilometres.

4.4. Results

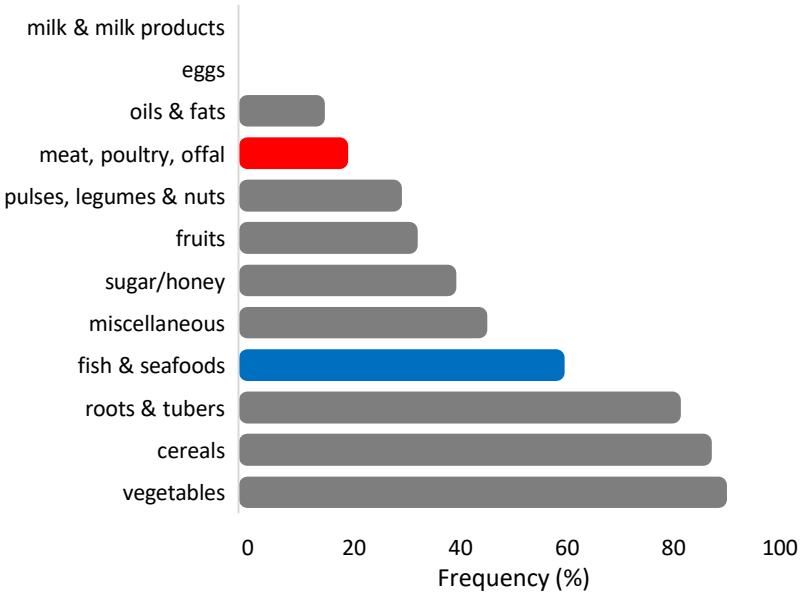
4.4.1. Dietary diversity and composition of household diets

Responses to the 24-hour diet recall survey illustrated that across the six farmer clusters, on average, the 68 households had consumed 5 ± 0.2 of the 12 food groups that comprise an optimal diet in the last 24-hours. Various households consumed as few as two and as many as nine food groups in the last 24-hours (Figure 8A). Only 41% of the households consumed more than five food groups – much less than the 10 food groups considered minimal for household nutrient adequacy. Overall, there was no significant difference between the number of food groups consumed by tilapia farming households and non-tilapia farming households and despite negative correlations between the number of food groups consumed and distance to coast (r=-0.230) and distance to market (r=-0.235), these variables were also not significant. The food groups consumed most frequently across all households were (in descending order) vegetables, cereals, roots and tubers, and fish and seafood (Figure 8B). Understandably, milk and milk products, as well as eggs were completely absent from household diets in the study site. Fish and seafood were the ASF consumed by most households in the last 24-hours. Notably, in this 24-hour period, more tilapia farming households (64%) consumed fish and seafood than non-tilapia farming households (53%).

A


0%
0%
100%
Poor
2-9 groups
Minimum
10 groups
Optimal
11-12 groups

B


milk & milk products
eggs
oils & fats
meat, poultry, offal
pulses, legumes & nuts
fruits
sugar/honey
miscellaneous
fish & seafoods
roots & tubers
cereals
vegetables
0
20
40
60
80
100
Frequency (%)

C

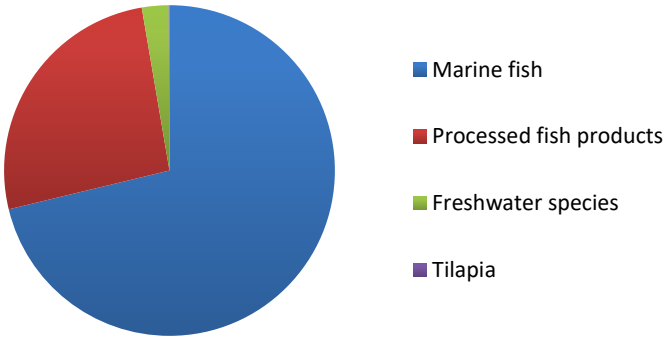

Marine fish
Processed fish products
Freshwater species
Tilapia

Figure 8: (A) The number and proportion of households consuming nine or fewer food groups (considered to be indicating an inadequate diet); at least 10 food groups (considered by Mekonnen et al. (2020) to be the minimum necessary to improve nutrient adequacy); and between 11 and 12 food groups (considered to indicate an optimal diet). (B) The proportion of households (n=68) consuming the 12 food groups in the last 24-hours. In this period, none of the households consumed eggs, or milk and milk products. (C) Estimates of the proportion of fish types (marine fish, processed fish products, freshwater species, and tilapia) that make up the total weight of fish consumed by each household in the last seven-day period.

The 24-hour recall data were collected in the wet season. Hence, in trying to understand potential differences in diet between seasons, household interviews were conducted to prompt reflections on seasonal effects. According to the focus group discussions which were used to specify the seasons recognised in the study area, two distinct seasons were identifiable; a wet season that extends from November to March and the dry season that commences in April and continues until the end of October. Irrespective of the season (either wet or dry), the top four food groups consumed by most households remained unchanged; with roots and tubers, vegetables, fish and seafood, and cereals (in descending order) consumed consistently by most households. Fish and seafood were consumed in similar proportions in wet (49%) and dry seasons (40%) respectively.

Despite 13% of households reporting they consumed oils/fats in the 24-hour recall, respondents did not indicate consumption of oils/fats in either season; this may indicate a limitation and lower sensitivity of data from the longer recall period.

4.4.2. Composition of animal source foods consumed by households.

In addressing the second research question, responses of the seven-day recall interviews were analysed to understand the relative consumption of the range of ASF types. The consumption of non-fish products was relatively low, dominated by poultry (obtained from both local free-range and store) and with very few households recalling the consumption of any bush meat, canned meat, or other meat. The seven-day recall revealed processed fish products (predominantly canned tuna) were consumed by 82% of households, relative to only 49% who consumed marine finfish (consisted of 47% pelagic and 53% reef-associated species) (Figure 9). Processed fish products were consumed by 20% more households than those that consumed any other type of fresh fish (i.e., combining households that had consumed fresh marine fish, freshwater fish, other seafoods and/or tilapia).

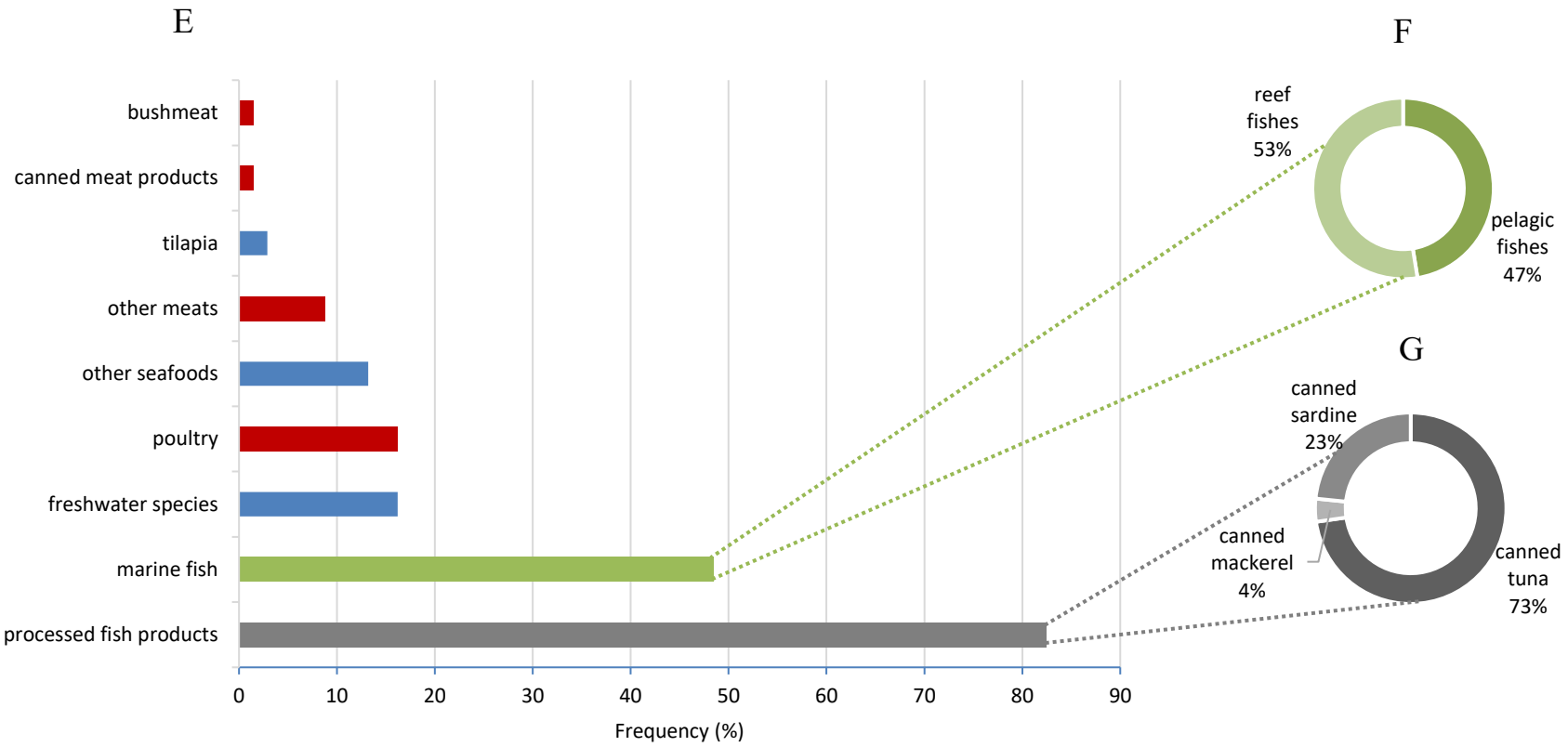


Figure 9: (E) Frequency (in percentage) of households recalling the consumption of the various ASFs in the last seven- days. (F) Doughnut chart depicting the percentage of reef fish and pelagic fish comprising *marine fish* consumed by households. (G) Doughnut chart depicting the composition (in percentage) of the canned mackerel, canned sardine, and canned tuna that make up *processed fish products*. The red bars show non-fish ASFs. 'Other seafoods' comprise other marine invertebrates, while 'other meats' included canned or processed meats, excluding fish.

Data from the previous seven days also revealed that for 21% of the households, processed fish products were the only ASF that had been consumed. For another 7% of the households, fresh fish (which include marine fish, freshwater species, tilapia and other seafoods) was the only ASF consumed. Only 7% of households had not consumed any ASF at all in this period.

Each household (n=68) indicated that in the last seven-days[8] they consumed around 3.9 ± 0.88kg of fish (fish here refers to all the fish types combined, including processed fish products). On average, each household comprised five household members; thus, this equates to about 0.97 ± 0.19 kg of fish eaten by each person during the seven-day period. A median score was used to compare fish consumption across household types because there were some extreme outliers overly influential on the mean. In tilapia farming households, 0.45kg (range of 0 to 2.39kg) of fish were consumed per person in the seven-day period, somewhat similar to the 0.40kg (range 0 to 8.95kg) of fish consumed per person in non-tilapia farming households in the same period. The Mann-Whitney U-test revealed no significant difference between the median weights of fish consumed per person in the last seven-days among household types, at a 95% confidence level. Furthermore, of the weight of fish each household consumed in the seven-day period, marine fish accounted for approximately 71.4%, processed fish products 25.9%, freshwater species 2.6%, and tilapia only 0.1% (Figure 8C).

4.4.3. Fish consumption patterns with proximity to coasts and markets.

To understand the variation of fish consumption based on geographic determinants (i.e., distance to most frequently accessed market and distance to the coast), correlation analysis was conducted on per capita fish consumption in the last seven-day period with the distances calculated between the GPS coordinates (for distance to market and coast). Analysis of this illustrated a significant but negative relationship (p=0.05, r=-0.243) between per capita fish consumption and households' distance to the coast and no significant relationship between per capita fish consumption and distance to market. When separated by household types (tilapia farming and non-tilapia farming households), the correlation analysis revealed no significant relationship between per capita fish consumption and distance to coast or market.

[8] Our calculation was based on per capita fish consumption in the seven-day period, and not per year. We did not extrapolate to fish consumption per year, because we cannot assume the per capita fish consumption in the seven-day period is indicative of every week in a year.

4.5. Discussion

A range of strategies are proposed by governments, development agencies and non-government organisations and are being implemented to ensure the trends of increasing malnutrition amongst people living in the Pacific Islands region are reversed. Maintaining locally sourced, fresh produce is key amongst these strategies (Hughes & Lawrence, 2005). Amidst these food-based strategies, there is recognition that consumption of fresh fish will remain critical in preventing or overcoming micronutrient deficiencies, particularly where household diets are rich in starchy products. This is particularly important for women of reproductive age, pregnant or breastfeeding and their infants (Albert et al., 2020). In the subsequent sections, I discuss the empirical findings on the role and limitations of small-scale tilapia aquaculture in providing a supplementary supply of fish for households.

4.5.1. Composition and dietary diversity of households

Dietary diversity is a widely recognised indicator of diet quality and a standard predictor of adequate intake of essential nutrients (Ruel, 2003). Data presented in this chapter revealed that most (59%) households consumed, on average, five or fewer of the 12 food groups, irrespective of whether they were farming tilapia or not. Adequate household dietary diversity is considered to be attained when at least 10 of the 12 food groups are consumed (Mekonnen et al., 2020). In the current study, all of the households surveyed had inadequate diversity in the foods that they consume for a healthy and productive life. This finding is supported by other research conducted in Malaita Province (Albert et al., 2020; Horsey et al., 2019; Vogliano et al., 2021) and in Fiji (Eme et al., 2019), Kiribati (Goris et al., 2016; O'Meara et al., 2019) and Tonga (Veatupu et al., 2019). While there are limitations to what can be understood from household-level dietary diversity, intra-household distribution of food can also have important effects on household diets, however, this was beyond the scope of this study. Few studies conducted in Malaita Province have examined intra-household dietary diversity, especially among specific household groups (e.g., women, children, and adult household members) (Albert et al., 2020; Horsey et al., 2019). For instance, Horsey et al. (2019) found the average dietary diversity score for 133 individuals (aged between 17 and 72 years of age) was 7.27 (with a range of between 2 to 12 food groups consumed) – this was in Auki township, the headquarters of Malaita province. Among rural children and women, Albert et al. (2020) also found a much lower dietary diversity, with an average of 2.9 consumed with a range of between 2 to 3 for a total of 10 food groups.

There are a number of strategies that are needed to improve diets and nutrition outcomes for people experiencing low dietary diversity in developing countries. Two leading strategies are to: (1) diversify local farming practices into alternate or improved and suitable varieties of crops (Andersen et al., 2013; Ecker, 2018; Jones et al., 2014a); and (2) increase public awareness of what constitutes a healthy diet (Albert et al., 2020; Horsey et al., 2019). Diversifying into alternate foods (especially fish or fish-based products) can introduce food groups that households or individuals might be missing and can play a vital role in addressing food security concerns such as stunting in children under five years old – a trend that is common in Solomon Islands (Albert et al., 2020). Yet there are existing local norms, cultural practices and preferences that may run counter to the proposed strategy (diversify into alternate crops) that needs to be recognised and addressed before it can be impactful. For instance, in the Pacific Islands region, local and traditional perspectives on the association between processed food consumption and increased social status imply that consumption of leafy greens is associated with low socio-economic status (Lyons et al., 2014). This implies some locally available leafy greens which are rich in essential nutrients are not widely consumed (ibid). This, therefore, leads to the second strategy whereby raising awareness on what constitute healthy diets, nutrition, and food preparation can be a useful tool. This has been trialled, for example, in school programs and is increasingly changing local perceptions and leading to greater consumption of leafy greens, especially among school children (Lyons et al., 2020). A similar approach can be applied to the study site in Solomon Islands as a way forward to addressing the issue of limited household dietary diversity as revealed in this chapter.

4.5.2. The extent of marine fish processed fish products, freshwater species, and tilapias' contribution to animal source food consumption.

In developing countries, national averages suggest fish as the most highly consumed ASF (Béné et al., 2015). In this study, while households have access to a range of fish types, processed fish products were the most commonly consumed. Tilapia from aquaculture contributed negligibly in terms of both frequency and quantity of fish products consumed by households. While this finding is contrary to studies by Asiedu et al. (2016); Eltholth et al. (2015); Toledo et al. (2008) and Dey et al. (2000), it is reflective of the fish consumption pattern in PICTs (Bell et al., 2019; Charlton et al., 2016; Cleasby et al., 2014). Two points are important to highlight here. First, considering the limited contribution of small-scale tilapia

aquaculture production to household fish consumption, the role of processed fish products in addressing fish poor diets should be further explored; this is given its (processed fish products) popularity among households as an animal protein source. Second, fresh marine fish will remain an important fish type consumed by rural households who have access to it; thus, efforts to manage and sustain production from coastal fisheries must be maintained and further strengthened to preserve this food and nutrition security foundation.

Small-scale tilapia aquaculture is yet to play a significant role in rural household diets. The finding of this study is consistent with few studies conducted in Africa by Mwanja et al. (2007) and Brummett et al. (2008) where fish farming contributed minimally to food security and livelihood. Yet the finding contrasts to studies by Asiedu et al. (2016); Karim and Little (2018); Karim et al. (2017) and Irwin et al. (2020) who found small-scale fish farming contributed to improved fish consumption and food security of participating households. The potential of supplementary fish production sources like small-scale tilapia aquaculture to deliver positive outcomes may hinge on factors like, but not limited to: (1) location (e.g., relative access to the fish source, rural or urban, proximity to a fish market, etc.) (Ahmed et al., 2017; Beveridge et al., 2013; Speedy, 2003); (2) income level, which can influence preference for fish type (Genschick et al., 2018; Gordon et al., 2013); and (3) seasonality, which can affect the price and availability of fish types during certain times of the year (Belton et al., 2011b; Karim & Little, 2018). For example, Belton et al. (2011b) described that in rural Bangladesh wild fish captured from inland fisheries is the most consumed fish type among the rural poor, while farmed fish (e.g., tilapia and Pangasius spp.) were dominantly consumed in urban centres. In Zambia, poor households primarily consumed small-fish species from capture fisheries (inland fisheries) because of their small size making them easily affordable while wealthy households consumed large-sized, fresh fish from aquaculture like tilapia which are usually sold fresh or frozen, but also because they are imported (Genschick et al., 2018).

In this study, the influence of location and preference may be key in limiting the contribution of small-scale tilapia aquaculture toward livelihoods and food security. In comparison to its small land area of 28,000km^2, Solomon Islands has a large marine area relative to its land mass. This is further reinforced by the fact that >80% of the rural population are coastal dwellers living within 5km of the coast (Andrew et al., 2019; Foale et al., 2011). Subsequently, there is a heavy dependence and reliance on marine resources for subsistence and economic

purposes (Asian Development Bank, 2014; Jupiter et al., 2019). This also means that people's preference for food fish is skewed toward marine fish, away from fish from other sources (e.g., from small-scale tilapia aquaculture) (Bell et al., 2009; Cleasby et al., 2014; Secretariat of the Pacific Community, 2013). Additionally, though tilapia was introduced in Solomon Islands in the 1950s (Eldredge & Humphries, 1994), its domestication in aquaculture is relatively new to most of the local population. Consequently, for tilapia to contribute significantly to household fish consumption, initiatives promoting its aquaculture development in rural areas should consider and explore ways to increase its overall acceptability as a food fish first (Scholtens & Bavinck, 2017). Possible ways to ensure this can be through value-adding and processing of the harvested product, to facilitate its wider acceptability. To date, very few ways and methods of cooking and preparing tilapia are apparent among tilapia farming households, some of which included tilapia deep fried in oil (coated with flour or not), boiled tilapia (see Figure 6) and tilapia cooked in coconut milk (personal observation). If additional ways and styles of cooking and preparing tilapia are introduced that fit in well with local preferences and popular local fish dishes, then it may boost and facilitate wider local acceptance of tilapia as fish food among local consumers. A study conducted in Samoa on value-adding of tilapia products revealed consumers highly preferred tilapia fish paste, compared to salt-cold smoked or cure-cold smoked forms (Lako et al., 2018). This study reaffirms that value-adding of tilapia can boost its acceptability especially among Pacific Islanders who are well-versed with marine fish, thereby ensure tilapia from aquaculture meaningfully contribute to household food security.

The current limited contribution of tilapia to household fish consumption in Malaita Province and the high consumption of processed fish products implies it can potentially contribute to food security by providing another complementary yet convenient, healthy, and shelf-stable source of food fish (Bell et al., 2019). Studies by Bell et al. (2019); Cleasby et al. (2014) and Jones et al. (2014b) also support this finding by validating the popularity of processed fish products (mostly canned tuna) among households in Solomon Islands. Among ten rural communities in central Malaita Province (some of whom also host the tilapia farming households involved in this current research), Jones et al. (2014b) found that the popularity of canned fish consumption as an ASF was because of its cost-effectiveness, accessibility, and long shelf life. Bell et al. (2019) have shown that Solomon Islands has the second highest annual per capita consumption of canned fish at an average of 5.9 ± 0.6kg after Fiji. In Solomon Islands, considering the present evidence where tilapia is not significantly

contributing to household fish food, processed fish products can contribute to filling the gap between coastal fisheries production and the current demands for fish. However, the role of processed fish products in contributing to household nutrition needs to be explored in future discussions. This can help in promoting its wider consumption in the community as a complementary, healthy ASF.

Fresh marine fish will remain an important fish type consumed by rural households; subsequently, efforts to manage and sustain production from coastal fisheries must be maintained and strengthened. The high portion of marine fish (71%), relative to combined fish weights (kg) that households surveyed consumed, details the dominance and importance of marine fish in local diets. Studies by Albert et al., (2020), Cleasby et al., (2014), and Horsey et al., (2019) supported this finding in Solomon Islands, while studies by Bell et al. (2009) and Charlton et al. (2016) also acknowledged similar fish consumption patterns across the broader Pacific Islands. Other fish production sources will likely only play complementary fish production roles to coastal fisheries for now in Solomon Islands (Albert et al., 2014; Jones et al., 2014b; Rabbitt et al., 2019; Weeratunge et al., 2011).

4.5.3. Per capita fish consumption varies with distance to coast, but not distance to market.

Fish consumption in developing countries is influenced by a number of factors, one of which is the proximity to fish production sources (Beveridge et al., 2013; Speedy, 2003). In this study, households that were closer to the coast were observed to have a higher level of access to fish consumption than those further inland. There was however no relationship between fish consumption and distance to markets. Analysis conducted in this study revealed a negative but significant correlation coefficient score (p=0.05, r=-243) between per capita fish consumption and distance of households to the coast. This implies that as the distance of households to the coast increases (i.e., advances inland), household per capita fish consumption decreases. This was irrespective of whether households were practising small-scale tilapia aquaculture or not. In Solomon Islands, lower access to fish experienced by inland populations means this portion of the population is more vulnerable to potential micronutrient deficiencies, especially those provided by fish (Bell et al., 2009).

Two strategies that can increase the availability of fish to these inland communities include

undertaking small-scale tilapia aquaculture and increasing supplies of non-perishable canned fish products (Bell et al., 2009; Bell et al., 2019). For instance, in PNG where a significant portion of its nine million[9] inhabitants reside inland, access to fish protein is limited. This has contributed to increased rates of malnutrition among the inland population, especially among vulnerable groups like children (<5-year-old) and pregnant women (Landi et al., 2016). Consequently, as early as in the 1990s, the PNG government initiated measures to address the widespread nutrition insecurity; through freshwater fish stock enhancement exercises (e.g., the Sepik River Fish Stock Enhancement Project, and the FISHAID project) (Coates, 1997), and the promotion of small-scale aquaculture (Smith, 2013). The latter, among other reasons, was intended to address improved nutrition of inland households through increased availability of fish thus tackle the increasing cases of malnutrition (Smith, 2013).

Furthermore, as Bell et al. (2019) has suggested, increased supplies of processed fish products to inland households can be another potential way to increase their consumption of fish. However, this can only be supported through the availability of essential infrastructures such as roads connecting interior communities to markets (Allen et al., 2005), at the same time ensuring an effective delivery network is established to sustain the consistent supplies of processed fish products overtime (Bell et al., 2009).

Results of this study also show that there is no significant relationship between distance to markets and household per capita fish consumption. While this finding demonstrates that access to market may have minimal bearing on household fish consumption, this was contrary to the findings of studies that looked at various influences of market access (e.g., Brewer et al., 2012; Brewer et al., 2009; Chaves et al., 2017; Koppmair et al., 2017; Zhong et al., 2018). For instance, Brewer et al. (2012) found that in Solomon Islands, fishing pressure on coral reefs was a function of access to markets which led to negative effects on the diversity of coral reef species. In their earlier study, Brewer et al. (2009) also highlighted that proximity to market also heavily influence biomass of specific reef fish fishery (e.g., Scaridae). In Malawi, Koppmair et al. (2017) found that the shorter the distance to the market (which was measured by time), the higher the household dietary diversity. These aforementioned studies, and the

[9] According to the https://devpolicy.org/what-is-the-population-of-papua-new-guinea-20210202-1/ the exact population size of PNG is not known because of no recent national census since 2011, but is estimated to be between 8 to 9 million. However, the authors of the blog estimated based on their calculations that the actual population might be around 9.5 million.

present research, puts into perspective that the impact of access to markets may be highly variable and dependent on the goods or commodity of interest and context under consideration (Baltenweck & Staal, 2007). For instance, in some rural villages in Malaita, fresh fish may only be available in the village or roadside markets occasionally. Moreover, once fish is available, they are prone to spoilage if left exposed for too long on the market stalls – due to lack of proper storage facilities (Jones et al., 2014). This limits the functionality of markets in-terms of fish supply, therefore restricting the possible influence of proximity to markets on household fish consumption. Furthermore, fish types, like processed fish products, are not necessarily sold at markets, but rather by small roadside canteens or stores (ibid). Hence, accessibility of these roadside canteens by remote and inland households should be an area for future research, to explore their influence on household fish consumption, especially processed fish products.

4.6. Conclusion

Despite the investment in, and sustained uptake of small-scale tilapia aquaculture in many PICTs, there is currently limited empirical evidence of the contribution toward food and nutrition security and rural livelihoods. This study has found that if households have good access to coastal fisheries, the interest in tilapia consumption will likely be negligible. Most households rely on and prefer processed fish products as a complementary source of fish. In any food-based strategy to address the malnutrition trends across the Pacific Islands region, intra-household distribution (food allocation among household members), differential nutritional needs and vulnerabilities amongst populations, local food cultures and preferences will be critical in avoiding the problematic assumption that simply increasing fish production will support food security.

CHAPTER 4 SUMMARY: Contribution of tilapia relative to other animal-sourced foods, in household diets

Governments, non-government agencies, and researchers in the Pacific Island countries are seeking options to help address the rise of malnutrition. Small-scale tilapia aquaculture is one option being explored to help address micronutrient deficiencies (one form of malnutrition) experienced by some people in the Pacific. While the idea of small-scale tilapia aquaculture appears to be popular and increasingly supported by local governments, there is insufficient evidence to determine if such investments will lead to increased consumption of farmed fish and substantive improvements in diet quality of rural households. To address this gap, I conducted 24-hour, seven-day, and seasonal food consumption recall interviews with 68 households (36 tilapia farming and 32 non-tilapia farming) in rural Solomon Islands. Household dietary diversity scores indicated both tilapia farming and non-tilapia farming households consumed an average of 5 ± 0.2 food groups per day, which is well below the recommended 12 food groups for optimal household diet. Vegetables, cereals, roots and tubers, and fish and seafood were the 4 food groups consumed by most households. Of the animal source foods, 82% of households consumed processed fish products, and 49% consumed fresh marine fish. From recall across a seven-day period, I estimated per capita fish consumption was 0.97 ± 0.19kg, where marine fish accounted for 71.4%, processed fish products 25.9%, freshwater species 2.6%, and tilapia only 0.1% of all fish consumed by weight. I found that fish consumption and distance to the coast were significantly, negatively related (p=0.05; r= -0.243); i.e., households further inland consumed relatively less fish. This pattern held irrespective of whether households undertook small-scale tilapia aquaculture or not. The present findings suggest that, despite investment and uptake of small-scale tilapia aquaculture, rural, remote, and inland populations still consume marine fish and processed fish products in preference to tilapia which contributes negligibly to food security. This chapter found that a more nuanced approach than just increasing fish production through small-scale fish farming is needed to address food and nutrition security concerns and preferences of rural populations.

A version of this chapter is currently prepared for publication in the *Aquaculture Research Journal*

5. Chapter 5: Roles, barriers & opportunities of small-scale tilapia aquaculture in Solomon Islands – perspectives from formal institutional actors

5.1. Preface

Factors dictating the contribution and value of SSA to livelihoods and food security are not only socio-cultural or economic but also include the role of institutions (as outlined in Chapter 1). Institutions are important as they can provide the enabling environment through targeted policies, legislation and strategies that can support the growth and expansion of the SSA sector. A lack of support from institutions can therefore have adverse effects on the growth of SSA and its contribution to livelihoods and food security. In my previous experience working with tilapia farmers in Malaita Province, I observed that support from institutions was paramount in supporting small-scale tilapia aquaculture. This observation was not only during the lifespan of the project (where it was supported by external institutions) but also after project support has lapsed - where farmers eventually discontinued farming tilapia after some time, raising the issue of long-term sustainability of the activity among farmers (see Harohau et al., 2016). Exploring the roles of institutions in supporting small-scale tilapia aquaculture is important to identify the challenges and opportunities for the success of the livelihood activity.

5.2. Introduction

With the Pacific Islands population expected to increase by 50% by 2030, an additional 115,000 tons of fish will be required to maintain the current fish consumption levels of Pacific Islanders (Bell et al., 2009; Secretariat of the Pacific Community, 2008). Tropical coastal fisheries are limited in their productivity due to limited management, unsustainable fishing, agricultural and coastal development, and the effects of climate change (Lam et al., 2020). As such, diverse fish production sources are necessary to supplement coastal fisheries production for local food security (Bell et al., 2015a; Bell et al., 2009).

Small-scale tilapia aquaculture is one potential fish production source that is currently being practiced in the Pacific Islands region to supplement fish for household consumption (Bell et al., 2013; Pickering, 2010; Ponia, 2010). This is because of its low technical and maintenance requirements which are suitable for rural farmers with limited access to resources like finance, labour, etc. (Edwards, 2013). In Asian and African countries, where small-scale tilapia

aquaculture has been practiced for some time, it has been shown to contribute significantly to the livelihoods and food security of poor fish farmers (Ahmed & Toufique, 2015; Asian Development Bank, 2005; Castine et al., 2017; Pant et al., 2014).

While emerging literature advocates for the need to understand the socio-cultural and economic context of SSA (Krause et al., 2020; Morgan et al., 2016; Slater et al., 2013), it is equally imperative to understand the perspectives and experiences of formal institutions supporting the sector. Institutional perspectives are crucial in contexts where SSA is not a traditionally embedded activity but introduced via external agencies (Morse & McNamara, 2013). In PICTs, increased and sustained engagement of institutions with rural fish farmers is essential to minimise adoption barriers of SSA and to ensure long-term sustainability (Amos et al., 2014).

In this chapter, institutions are organisations or agencies which under appropriate laws and regulations, have the legal mandate to perform specific functions and roles (Hodgson, 2006; Hodgson, 2007). These institutions may include, the appropriate government departments or divisions, non-government organisations, development agencies and research institutions. Furthermore, though the roles, functions and responsibilities of these institutions may be wide-ranging, they may include designing and formalising policies pertinent to aquaculture development; providing micro-finance for fish farmers; or the provision of extension services and technical support (Ahmed, 2009; Ahmed et al., 2008a). At the much higher level, the aquaculture governance structure postulated by Hishamunda et al. (2014) asserts that institutions lay the foundation for specific strategies (e.g., foreign investment, research and risk analysis), which in turn lays the foundation for instruments (i.e., demand and supply), and communications (i.e., the social license) for aquaculture SSA development. In Solomon Islands, important institutions concerned with SSA development included:

1) Government agencies (e.g., Ministry of Fisheries and Marine Resources[10], Ministry of Agriculture and Livestock, Ministry of Lands, Ministry of Environment, Conservations and Meteorology).
2) Non-government agencies (e.g., WorldFish and the Worldwide Fund for Nature); and

[10] The Ministry of Fisheries and Marine Resources (MFMR) is the lead government organisation with statutory mandate to manage and regulate fisheries and aquaculture development in Solomon Islands (Solomon Islands Ministry of Fisheries and Marine Resources, 2019).

3) Regional organisations (e.g., Foundation for the Peoples of the South Pacific and the Pacific Community (SPC)). The only locally formed institution identified was the Solomon Islands Locally Managed Marine Areas (SILMMA).

4) Tertiary institutions (e.g., Solomon Islands National University and rural training centres).

In countries like Bangladesh, institutional support through donor-funded initiatives is responsible for an increase in SSA production (Pant et al., 2014). Ndah et al. (2011) also highlighted that increased uptake of fish farming in rural Cameron was facilitated through support from institutions. Conversely, a lack of appropriate institutional support may hinder the achievement of desirable outcomes from SSA. For example, in Philippines, the government's action plan for aquaculture development was only a wish-list, as there was no capacity for implementation, and there was no political will to support the sector (Fernandez, 2013). Brummett et al. (2008) also alluded for Africa in general, that ineffective institutions and donor-funded projects with huge investments to develop SSA in the region had not resulted in tangible impacts on rural fish farmers' livelihoods or food security. These literature on institutions and fish farming in Asia and Africa have identified that support from institutions to SSA development is paramount and can be via research, extension services, basic and adaptive research for the development of low-cost technologies for farmers, training, and financial support through funded projects (Ahmed & Toufique, 2015).

Across the Pacific Islands region, there is evidence of growing support from institutions through the creation of specific policies and strategies targeting small-scale tilapia aquaculture development (Amos et al., 2014). However, few studies have explored the implementation experiences of these institutions including the challenges encountered. Subsequently, understanding the implementation challenges experienced by institutions is important as successes of SSA in one country (e.g., positive impact on food security) may not be easily replicated in another country, due to unique situational factors enabling or constraining these successes at the organisational level.

In this chapter, the perspectives of three institutions are explored. In Solomon Islands, most SSA initiatives (as is true for the rest of the Pacific Islands region) are initiated by external institutions. This drive by external institutions calls into question the long-term sustainability

of SSA initiatives as they are mostly dependent on support from these institutions. In this chapter, the basis by which appropriate steps can be taken in the policy domain to support the development of SSA in the form of small-scale tilapia aquaculture is detailed. To support this, the following five research questions are proffered:

1) What roles are relevant institutions currently playing to support development of the small-scale tilapia aquaculture?
2) What are the key institutional milestones achieved to date with tilapia aquaculture?
3) What important lessons have institutions learned from their experience supporting small-scale tilapia aquaculture to date?
4) What are the barriers hindering the development of small-scale tilapia aquaculture to date, as perceived by institutions involved?
5) What are the opportunities for further driving the uptake of small-scale tilapia aquaculture?

5.3. Methods

5.3.1. A brief overview of institutional support for small-scale tilapia aquaculture in Solomon Islands

Though the history of SSA in Solomon Islands can be traced back to the 1950s, recognition of the sector at the policy level has only occurred recently (Solomon Islands Ministry of Fisheries and Marine Resources, 2019). Official MFMR records show that SSA started in the 1960s when gold-lip pearl oyster aquaculture was first trialled in Wagina, Choiseul Province. During the 1980s and 1990s, other commodities such as the giant river prawn (*Macrobrachium rosenbergii*), seaweed, and marine shrimp were established. However, it was not until the 2000s when an aquaculture unit was established within the Ministry of Fisheries and Marine Resources (MFMR) that considerable efforts and resources were allocated to developing SSA in Solomon Islands. This eventually led to the formulation of the first Aquaculture Development Plan for the period 2009-2014 (Ministry of Fisheries and Marine Resources, 2009). The establishment of this policy provided the government with a clearer and more defined path in achieving its aspirations of developing a robust aquaculture sector that could contribute to national revenue and improve food security. Moreover, the development of the aquaculture policy also provided the basis by which the government through its responsible institutions such as MFMR was able to establish partnerships and

collaborations with other relevant institutions to co-develop the aquaculture sector in Solomon Islands.

The Aquaculture Development Plan 2009-2014 was the first formal document to highlight the potential commodities for aquaculture in Solomon Islands (Ministry of Fisheries and Marine Resources, 2009, 2018). In this plan, tilapia was ranked within the top four commodities for SSA development based on its feasibility and potential impact on livelihoods and food (ibid). This forced the government to come up with a more detailed plan highlighting the specific actions, targets, and measurable indicators that explicitly focused on small-scale tilapia aquaculture. In 2009, MFMR with support from other partners (e.g., which include other government ministries, regional and international organisations, community reps and community-based organisations) formulated the Solomon Islands Tilapia Action Plan 2010-2015 (Ministry of Fisheries and Marine Resources, 2010). This plan instigated a series of activities focusing on small-scale tilapia aquaculture development for livelihood and food security. One of the first was a partnership project undertaken by WorldFish, MFMR and SPC from 2011-2015. This externally funded project was implemented in rural communities in Western, Guadalcanal, and Malaita Provinces (Sulu et al., 2015a). Lessons from this project contributed immensely to informing the recently formulated Aquaculture Management and Development Plan 2018-2023 (Ministry of Fisheries and Marine Resources, 2018). Under this plan, tilapia remained a high priority aquaculture commodity.

5.3.2. Research approach

In this chapter, a non-probability sampling strategy was used based on a purposive sampling technique (Ritchie et al., 2013). This technique involved identifying relevant institutions based on a single criterion. This criterion was that institutions must have had some form of engagement with small-scale tilapia aquaculture – either in the past or currently.

A total of five institutions were initially identified as meeting the criteria stated above. These included the Ministry of Agriculture and Livestock, MFMR, Adventist Development Relief Agency (ADRA[11]), World Vision, and WorldFish. However, only three institutions, MFMR,

[11] ADRA's involvement with small-scale tilapia aquaculture was through their Youth Engagement and Livelihood Project in East Guadalcanal (also in Malaita Province) which was funded by the Australian Government. The project used a "strength-based" approach where communities themselves identify their livelihood needs (e.g., copra, melon farming, marketing, etc.) and inform the project for support. Hence, in inland North-East Guadalcanal (at Gesa community) where data shared here by ADRA was based, the community identified

WorldFish and ADRA positively responded to my request for an interview. Responses from these three organisations provided the data analysed for this chapter. I categorised these institutions as governmental, non-government organisation, and faith-based organisation respectively. One representative from the non-government organisation and one representative from the faith-based organisation were selected. For the government institution, three staff within the Aquaculture Division were identified for interviews. Altogether, a total of five people across the three institutions were interviewed. All these people held roles and responsibilities that were pertinent to small-scale tilapia aquaculture development within their respective institutions.

5.3.3. Data collection

Written consent was obtained before all interviews were conducted. Face-to-face semi-structured interviews with the selected staff were used. Interviews were held at a particular person's place of work and conducted at an agreed time. On average, interviews took one and a half hours. All interviews were digitally recorded with participants' consent. Interview questions focused on the institution's role in small-scale tilapia aquaculture development. Questions included:

1) What important achievements has your particular institution attained with regards to the development of small-scale tilapia aquaculture to date?
2) What important lessons were learned about how best to support small-scale tilapia aquaculture development?
3) What are the imminent constraints to developing small-scale tilapia aquaculture further?
4) How were these constraints addressed by the institution?
5) What are the opportunities for developing small-scale tilapia aquaculture further? and
6) What is the institution's future plan for small-scale tilapia aquaculture development in Solomon Islands?

5.3.4. Data analysis

Data were transcribed and qualitatively analysed using an inductive approach (Creswell &

management of tilapia within a small lake in the community as one priority livelihood option; this was to ensure the community continuously supplemented their household diet with fish protein from tilapia – given their growing demand for fish and their limited access to marine fish. According to the ADRA staff interviewed, some villagers also constructed their own ponds on the side where they introduce and farm tilapia.

Poth, 2016). Specifically, recorded interviews were transcribed according to the five research questions. After transcribing, coding of the contents was conducted into re-occurring and emergent themes. Repetitive reading of the content was done to further validate the coding and themes. The resultant themes formed the basis of the following qualitative description.

5.4. Results

5.4.1. Current roles of organisations in tilapia aquaculture development in Solomon Islands

In analysing the current roles played by the institutions toward small-scale tilapia aquaculture development in Solomon Islands, two primary roles emerged including: (1) the provision of technical support and assistance to farmers; and (2) developing collaborations and partnerships between institutions.

Technical support and assistance were a common role played across all the institutions interviewed. Technical support included the production of locally appropriate information materials in the form of brochures, posters, and simple tilapia farming manual (see Figure 10) and distributing them to local communities and people interested in small-scale tilapia farming. Technical support also included extension work in physically assisting interested tilapia farmers with technical aspects like pond design, pond construction, and making appropriate feeds. Trainings and workshops were also part of this extension process. For ADRA, technical support was mostly directed at assisting a community in East Guadalcanal (Geza community) develop a management plan to manage harvesting tilapia from a small lake in the community, which provides a valuable source of fish protein to household diets.

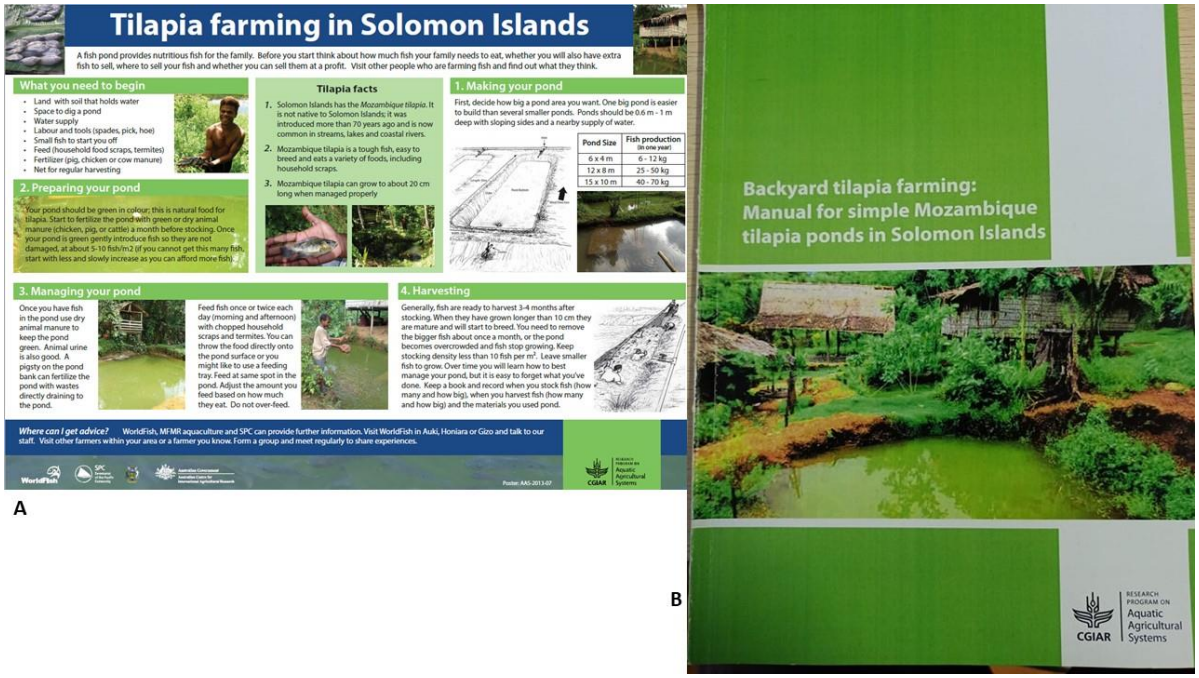


Figure 10: Examples of locally available information materials on small-scale tilapia aquaculture that were collaboratively produced with project farmers, and widely distributed to aspiring tilapia farmers and communities in Malaita Province, but also other provinces (e.g., Western Province). (A) Poster on basic management activities of the typical small-scale tilapia aquaculture ponds, (B) A locally formulated tilapia farming manual for ponds construction and management of tilapia ponds.

In describing their role of providing technical assistance to tilapia farmers, the WorldFish staff pointed out:

We assisted farmers to modify their pond designs factoring in impacts of climate change where continuous rainfalls can flood ponds or cause dykes to collapse. Some farmers attempted planting grass around their ponds.

A staff member from MFMR also reiterated the following in a similar statement:

Our on-going activities are to provide rural farmers basic training on tilapia farming. For instance, how to construct proper tilapia ponds, and for new farmers, introduce them to the concept of tilapia farming.

Institutions also played an important role in supporting collaboration and partnerships. This was evidenced by the different institutions playing essential support roles to each other, particularly in situations where concerns pertaining to small-scale tilapia aquaculture was beyond a particular institution's technical expertise and capabilities. For instance, in a farmers' workshop facilitated by WorldFish, tilapia farmers raised the need for a better-performing fish species to farm rather than the Mozambique tilapia. This concern was brought

to the attention of MFMR for consideration and to provide feedback to the farmers' inquiries. Another example of such collaboration was exemplified when individual members of the community where ADRA was working wanted more technical advice on pond design and construction. Because this was not within the technical reach or expertise of ADRA, both WorldFish and MFMR were consulted for their technical input and direction.

The following was described by a MFMR officer:
We teach the tilapia farmers on best available feed for their tilapia, and we are relying on the technical expertise of WorldFish and SPC.

The ADRA person commented:
Our community project officer also links community members or farmers to important organisations like WorldFish and MFMR. This is so community farmers can seek more information on tilapia farming.

However, it was apparent that MFMR was playing the leading role in supporting small-scale tilapia aquaculture development compared to both WorldFish and ADRA. MFMR has the core mandate to lead SSA development in Solomon Islands including:

1) Supporting rural tilapia farmers through both physical (e.g., tools and materials) and financial incentives (e.g., small grants, or in-kind).
2) Building technical capacity (e.g., skills and knowledge) of extension officers; and
3) Developing policies, strategies, and action plans for small-scale tilapia aquaculture development.

At the time of the interviews, financial assistance for the farmers was uncommon, according to both the officers interviewed and the tilapia farmers. The need for capacity building of both MFMR staff and tilapia farmers was also highlighted by interviewees. Currently, MFMR is understaffed, therefore, limiting the implementation of important milestones and activities. Subsequently, MFMR is currently making efforts to build up its human and technical capacity (e.g., recruiting new graduates and equipping them with relevant skills through training). Along these lines, MFMR has also been assisting interested tilapia farmers to build up their knowledge and skills for fish farming through on-site training and farm demonstrations.

Lastly, among the important roles played by MFMR has been the development of appropriate policies, strategies and action plans pertinent to SSA development in Solomon Islands with support from relevant stakeholders as well as SPC. Important plans mentioned by the MFMR staff included the *Solomon Islands Aquaculture Development Plan 2009-2014*, and the *Solomon Islands Tilapia Action Plan 2010-2015* (the *Solomon Islands National Aquaculture Management and Development Plan 2018-2023* was still being developed during my interviews). These plans, including the *Fisheries Management Act 2015* (Anon, 2015) were seen as essential in guiding the SSA development in Solomon Islands.

5.4.2. Key milestones of small-scale tilapia aquaculture development

Representatives of the three institutions interviewed highlighted key milestones that described the development of the small-scale tilapia aquaculture to date.

According to the interviewees, at the farmer level, the technical knowledge on small-scale tilapia aquaculture has increased and there is now broader awareness of small-scale aquaculture in rural communities. In reiterating this latter point, a MFMR officer stressed:
When I started work in 2008, tilapia as a commodity for aquaculture was not really recognised by rural farmers. This is different now and has been due to the increased awareness and trainings conducted with rural farmers.

At the institutional level, the approach now used to facilitate small-scale tilapia aquaculture development is a milestone in itself. In the past, the desire to farm tilapia was mainly driven from the top-down (e.g., imposed on communities by government or development agencies), whereas now the desire to farm tilapia is increasingly driven by farmers themselves. This involved interested farmers realising the need and potential for tilapia aquaculture and approaching relevant institutions to assist and support them. Diffusion has spread from the specific project sites with other people and groups taking up tilapia farming on their own, without assistance from extension services. Donor funded projects (e.g., ACIAR FIS/2009/061 & FIS 2010/057 projects[12]) were also important milestones that lent support to

[12] FIS/2009/061 and FIS/2010/057 were successive ACIAR funded projects implemented by WorldFish in partnership with the Government's Ministry of Fisheries and Marine Resources and The Pacific Community. FIS/2009/061 was initially implemented with the aim of assisting the Solomon Islands' Government better understand the need and future for aquaculture, while the subsequent FIS/2010/057 project was aimed at identifying the best mechanism for small-scale tilapia aquaculture that was applicable for Solomon Islands that could contribute to food and nutrition security (Sulu et al., 2015a).

the commitment of institutions in driving the development of small-scale tilapia aquaculture. These projects helped to introduce the idea and possibility of tilapia farming among local people in Malaita Province and also facilitated research that assisted and enabled a better understanding of other aspects of small-scale tilapia aquaculture (e.g., comparing the economics of tilapia aquaculture and other aquaculture commodities like milkfish). Outputs from the projects (e.g., reports, technical studies and peer-reviewed papers) also furthered the understanding of important aspects of tilapia aquaculture (e.g., nutrition, technical feasibility, etc.).

Specific to MFMR, the formation of an Aquaculture Division, followed by the formulation of the various aquaculture policies, strategies, and action plans were important milestones for developing small-scale tilapia aquaculture further. MFMR has also highlighted that more recently, there had been an increase in the provision of physical (not financial) support to rural farmers (e.g., provision of tools and pond materials), something that was seldom done before.

For ADRA, one milestone achieved from their work on small-scale tilapia aquaculture in the community was related to the social aspect of the community; that is being able to coordinate and organise the community to agree on and implement a common management plan for their shared tilapia resource, as well as respecting bylaws set by the communities. This was important in determining the success of livelihood projects on the ground.

5.4.3. Important lessons learned by organisations regarding small-scale tilapia aquaculture development.

Across all the institutions interviewed, five important lessons emerged:

1) Working with highly interested individual farmers to develop small-scale tilapia aquaculture has proven more effective than working with entire communities.
2) Understanding the diversity of interest in small-scale tilapia aquaculture across geographies (e.g., inland versus coastal) is critical for ensuring uptake.
3) Consistent communication between technical staff and tilapia farmers is critical for success.
4) Long-term financial commitment from institutions to support rural farmers is required for successful small-scale tilapia aquaculture development, but only where there is an actual need for tilapia aquaculture.

5) Technical capacity building for staff of implementing institutions is also required for successful small-scale tilapia aquaculture development in Solomon Islands.

First, when describing the importance of working with individual farmers instead of the entire community on small-scale tilapia aquaculture, MFMR officers highlighted:

At the moment, we are working with individual farmers, as opposed to working with communities. This is more practical and effective, especially when directing assistance to tilapia farmers.

In addition to this point, collaboration and partnership between relevant institutions were also found to be important and effective due to the relative newness of the small-scale tilapia aquaculture development in Solomon Islands. This collaboration between institutions was successful in driving important milestones.

Second, when reiterating the importance of small-scale tilapia aquaculture across diverse geographies, a MFMR officer stressed:

Our work has made us now understand the geographical spread of the acceptance of tilapia to certain places. In some places, it will work, while in others, it will not work.

Similarly, the WorldFish staff noted:

Those inland, and not the coastal are the right people to target. Coastal people have easy access to the sea, hence, a range of marine fish.

Third, a MFMR officer highlighted that maintaining regular communication with tilapia farmers was important in the absence of effective extension service. Regular communication has been facilitated mainly through mobile phones to ensure that tilapia farmers are updated on issues pertinent to their farming activities. Communication is also to disseminate information on assistance opportunities from the government or other institutions. This current arrangement of communication has been praised by tilapia farmers as it has motivated a number of them to keep going with their small-scale tilapia aquaculture activities. Facilitating relevant platforms for farmers-experts knowledge sharing and collaboration (e.g., targeted trainings and workshops) also reinforced the notion of regular communication and

has further expanded tilapia farmers' understanding of small-scale tilapia aquaculture and its potential benefits. Managing people's expectations was also another lesson learned. This involved being explicit with what tilapia farmers may be expecting from the government or other institutional support and engagement (e.g., through projects or community partnerships). This not only included communicating the right information to tilapia farmers but also information that was simple for tilapia farmers to understand.

As articulated by a MFMR officer:
When farmers are well informed, then their expectations are met.

The need for financial commitment was another lesson learned. At the time of interviews, MFMR's budget allocation from the national government had only recently been increased. Therefore, MFMR officers emphasised that the more government financially commits to small-scale tilapia aquaculture development, the greater the budget allocation will be, and more progress can be achieved; especially in places where there is a strong need for small-scale tilapia aquaculture. In addition to this, the MFMR officer contended that having the right policies and strategies in place also enabled effective implementation and progress of developing the small-scale tilapia aquaculture sector in Solomon Islands.

Lastly, it was also obvious that the improved technical capacity of staff was key for the successful implementation of project activities. As a MFMR officer highlighted, a shortage of technical staff (which is still a persistent issue) was responsible for planned small-scale tilapia aquaculture activities being implemented slowly, or not implemented at all.

5.4.4. Barriers to the development of the small-scale tilapia aquaculture sector

Common across the three institutions interviewed, two constraints were identified to small-scale tilapia aquaculture development. These were:

1) The slow growth rate of the Mozambique tilapia and, hence, its limitations for aquaculture; and
2) Limited market opportunities for tilapia in the local context.

Specific to MFMR, perceived barriers included:

1) A lack of financial commitment to developing the small-scale tilapia aquaculture, due to the unpopularity of Mozambique tilapia for SSA.

2) Limitations in institutional set-up and human resource capacity available to effectively implement the government's work plan and activities.
3) The limited support geared toward the technical aspects of tilapia aquaculture.
4) Ability to conduct awareness and support through extension services; and
5) An absence of a value-chain analysis for tilapia.

For ADRA, barriers to developing small-scale tilapia aquaculture were dominantly social aspects. These included the lack of community cooperation limiting the expansion of the activity and jealousy toward successful tilapia farmers leading to sabotage of pond infrastructures, which also discouraged further investment in the activity.

The characteristics of the current Mozambique tilapia has discouraged many potential farmers due to the lack of incentives it provides in compensation for their time and effort in tilapia farming. In particular, tilapia farming did not provide significant income. Subsequently, many tilapia farmers tended to abandon their tilapia farms and move into other livelihood activities that were more income generative. Also, in the absence of a market for tilapia, tilapia farmers were unable to sell their harvests for income. This eventually discouraged the long term sustainability of the activity among these tilapia farmers. As contended by the WorldFish officer:

There is no proper market for tilapia. Initially, tilapia farmers thought they will be able to sell their tilapia. When they could not, they eventually slowed down or became discouraged to continue tilapia farming.

Figure 11: The undesirable attributes of the current Mozambique tilapia include early reproduction, high fecundity, and stunted growth, resulting in too many small-size fish in the ponds. Photo credit: WorldFish, 2015.

MFMR staff also highlighted that financial commitment to the sector was vital. It was obvious that when there was strong financial pledge or support, expansion and progression occurred. As an accompaniment to this, MFMR staff also noted the limitation in terms of organisational set-up and human resources due to funding constraints. For instance, organisational set-up included having in place explicitly defined roles and responsibilities of technical staff within the Aquaculture Division which was previously and is still understaffed. Despite technical support and assistance being rendered to rural farmers, there is still a need for low-cost and appropriate feed, quality fingerlings and markets. With regards to feed to supplement natural food for tilapia in the ponds, there have been attempts to formulate feeds based on locally available ingredients, yet farmers have not taken this on board. This has generally limited the productivity of current farming practices, along with the enthusiasm by farmers to continue farming tilapia. The absence of essential support to improve and strengthen the current small-scale tilapia aquaculture value-chain (e.g., storage of harvests for later market, etc.) has also constricted the potential of the current activity to benefit local livelihoods and support food security. Lastly, though it was acknowledged that the government and partners have been providing extension services for farmers in rural areas on tilapia aquaculture, there is still more to be done. The current promotion of the concept of small-scale tilapia aquaculture has not been extensive enough, as there might still be rural farmers interested in the activity who have simply not been made aware of it.

Disputes over land and water also hindered small-scale tilapia aquaculture advancement. Another observation made was that all households in the community wanted a share in the project, or to receive direct assistance from the project. This promoted a barrier for projects wanting to work in a community through a model or pilot type approach, where only a few households received full and direct support. It was also observed that many tilapia farmers did not want to share their knowledge and experience with others in the same village, limiting the expansion of the activity within the community and beyond.

5.4.5. Identified opportunities to drive small-scale tilapia aquaculture forward.

Across the three institutions interviewed, the most highlighted opportunity they believed that could drive small-scale tilapia aquaculture forward was the introduction and farming of an improved and better-performing tilapia species in aquaculture. Nile tilapia was identified as a potential candidate and efforts are underway by the government to bring the species into Solomon Islands. As mentioned by the ADRA officer:

There will be a lot of enthusiasm to be involved in tilapia aquaculture if an improved tilapia species was introduced, as this will expand the sector.

A MFRM officer also reiterated:

Introduction of a more productive tilapia species is important because it will reduce culture time and increase profits for farmers, providing them incentives to continue farming.

Other opportunities that can be built on to drive the development of small-scale aquaculture forward included:

1) Rural inland communities that have limited access to marine fish and those farmers with genuine interest should be targeted and involved in tilapia aquaculture.
2) The growing population of Solomon Islands giving rise to increased demand for food and fish will eventually see people look to alternative sources like small-scale tilapia aquaculture to source their fish; and
3) Sharing correct, simple, and context-specific information and awareness materials for local farmers should remain a priority.

Specifically, for MFMR, highlighted opportunities were:

1) Continued government support in terms of providing essential start-up materials and financial assistance for rural farmers must improve, continue, and be more extensive (i.e., meaning other development agencies should also see this as an important aspect).
2) The development of a market promotion plan for the current tilapia species will help local customers familiarise themselves with tilapia; and
3) Existing training and capacity building of tilapia farmers and maintaining extension services to these tilapia farmers must be ensured and improved, to drive the sector.

MFMR staff further highlighted that the current process of strengthening the human resource and technical capacity within the Aquaculture Division needs to be supported in order for MFMR to be fully functional in implementing its work plans relating to small-scale tilapia aquaculture development.

The WorldFish officer also highlighted that climate change will also present an opportunity for expansion of tilapia aquaculture across many islands of Solomon Islands. This is because increased rainfall will be a bonus for inland communities that were previously deprived of reliable water sources for their tilapia ponds.

Both ADRA and WorldFish also highlighted that there may be a need to diversify the commodities for inland SSA. Alternate freshwater commodities that were suggested included prawn and milkfish. These species can be cultured in freshwater but are also locally available. This availability overcomes the need to import broodstock or fingerlings; though this also means supply from the wild must be consistent and enough for grow-out demands. As expressed by the ADRA officer:
There are other rural farmers wanting to venture into other potential commodities (e.g., shrimp farming). We reminded them that the technical feasibility of these commodities is not yet well established in our local context and will take time for it to happen.

Another opportunity mentioned by ADRA was that as people become more conscious about the need to keep their environment pristine; farming of wild Mozambique tilapia in ponds will only happen in places where the species has already established itself. In other words, this will mean that expansion and uptake of tilapia aquaculture will be likely to concentrate around

areas where there is already a presence of wild tilapia in natural waterways.

5.5. Discussion

Institutions are important as they play an influential role in shaping the development landscape of SSA (Brummett et al., 2008; Fernandez, 2013; Kumaran et al., 2012). Yet, in the Pacific Islands region, the perspectives and roles of various institutions have not been formally documented. This chapter aimed to address this gap via semi-structured interviews conducted with technical staff from three institutions engaged in small-scale tilapia aquaculture in Malaita Province of Solomon Islands. The results showed that, amid the various roles institutions play, the provision of technical assistance, collaboration and partnership building stood out. Locally, there has been an increase in technical knowledge and broader awareness of small-scale tilapia aquaculture in communities. From an institutional perspective, a key milestone achieved was the development of a more farmer-driven approach (i.e., as opposed to top-down). Institutions also learned that targeting the "right" people for tilapia farming ensured its uptake and long-term sustainability, while the geographical spread of small-scale tilapia aquaculture activities may also influence its success among fish farmers. Two key constraints identified by institutions were the poor traits of the Mozambique tilapia and limited market opportunities. Subsequently, the current initiative by the national government to introduce the Nile tilapia would be a positive step forward.

First, while it can be argued that the popularity of technical assistance and support played by various institutions to fish farmers may be due to the novelty of a new commodity and activity (Pouomogne et al., 2010), this may not hold true everywhere. For instance, in Thailand, Vietnam, Cambodia and Malaysia where farming fish has long been a tradition within local cultures, support from institutions remain a key aspect of the aquaculture sector's development. In these Asian countries support from institutions remained evident through established hatcheries, seed stock availability, demonstration and training for farmers, and capacity building of rural farmers (Bueno, 2008). In Solomon Islands, the presence and support from institutions toward small-scale tilapia aquaculture development will be necessary across all levels for some time to come. To strengthen this, collaboration and partnerships between institutions will remain vital. This is to ensure effective "pooling" of resources (e.g., technical knowledge, finance, etc.) (Baticados et al., 2014; Dornan & Newton Cain, 2014), bridge knowledge gaps, as well as providing access to critical resources (Guo & Acar, 2005). In Solomon Islands, this is crucial in instances where certain institutions (e.g., government) may

lack resources to effectively support tilapia farmers in the rural areas (Blythe et al., 2017).

Second, targeting the right people in rural communities presents another important condition for the successful implementation of new livelihood activities. As asserted by the institutions interviewed, the 'right people' implies those who are willing to pursue small-scale tilapia aquaculture as a supplementary livelihood based on their pressing need (e.g., limited access to fish protein, etc.). A New Zealand funded project on marine ornamental aquarium trade in Western Province from 2005-2010 addressed this by accepting only people with genuine interest and have applied for the project; the strategy was successful in that the retention rate of project activities increased from only 5% in the first year to 95% in the project's final year (The WorldFish Center, 2010). Studies by Keppel et al. (2012); Namudu and Pickering (2006) and Ploeg et al. (2016) also affirmed the importance of this aspect with different development interventions (e.g., seaweed aquaculture, conservation initiatives, etc.) across the Pacific Islands region. For instance, Ploeg et al. (2016) has highlighted that the WorldFish's Agricultural Aquatic Systems Program, which was implemented on Malaita from 2012 to 2015, employed two sets of criteria for selecting communities to work with:

1) There must be an expression of interest from communities to participate in the program.
2) There must be active community champions to help facilitate program initiatives.

Understanding the institutional perspectives on possible barriers to the development of small-scale tilapia aquaculture in Solomon Islands (and the broader Pacific Islands region) is critical for the sector's success. This can ensure that policies, strategies, and action plans pertinent to small-scale tilapia aquaculture are progressively amended to reflect the needs of the sector going forward. Institutions interviewed in this chapter have identified the current tilapia species as the top limiting constraint to the expansion of small-scale tilapia aquaculture. However, this constraint is not only a country-specific issue but rather a region-wide one to SSA development in the Pacific Islands region in general (Amos et al., 2014; Ponia 2010). In Nigeria, Akpabio and Inyang (2007) also highlighted that inadequate supply of fish fingerlings and unavailability of improved species were among the important constraints to aquaculture development. In Indonesia, the success of freshwater aquaculture production was attributed to, among other factors, farming of the tilapia species (*Oreochromis spp*.) in addition to the dominantly farmed carp (*Cyprinus carpio*) (Rimmer et al., 2013). In Solomon Islands, sourcing an improved species of tilapia or a better performing strain needs to be made a priority to overcome this current bottleneck and to ensure the maximum impact on local livelihoods and food security. A better performing tilapia species will ensure shorter culture time, more efficient usage of

resources (e.g., feeds), increase outputs (e.g., weight and number of fish), which in-turn can have maximum impact on food security (e.g., directly as a fish source, or sold for income) (Ministry of Fisheries and Marine Resources, 2009, 2010). The Solomon Islands' government has responded to this issue and is currently making necessary preparation (e.g., the establishment of hatchery) for the introduction of the Nile tilapia (*Oreochromis niloticus*) to replace the current Mozambique species, despite taking almost a decade to reach this stage (Ministry of Fisheries and Marine Resources, 2010, 2018). This is being conducted in partnership with in-country organisations and regional organisations, such as SPC.

5.6. Limitation and future directions

There were several limitations identified from this chapter that future research can build on. First, the relatively small number of institutions (three of the five) who participated in interviews may have given a constricted view on the scope and breadth of support institutions would have played. Secondly, a more elaborate study that also looks at the role of institutions and other networks that farmers rely on for undertaking the aquaculture sector would help to inform strategies at all levels (e.g., regional, national and local). A social network analysis would be more elaborate and detailed, especially in understanding connections established between tilapia farmers and where they obtain their support for small-scale tilapia aquaculture (be it be finance, advice, seeds). Such social network analyses are popularly used in capture fisheries (see Mueller et al., 2008; Stevens et al., 2015; Turner et al., 2014) and can provide a clearer picture of other key players in small-scale tilapia aquaculture development. Also, in the future, such studies on the roles of institutions in aquaculture development should extend beyond a particular case study context and make empirical comparisons across all PICTs.

5.7. Conclusion

Three key conclusions can be drawn from this chapter. First, institutions play a critical role in providing technical support and assistance to tilapia farmers. This may be illustrative of tilapia farmers' limited capacity to undertake and sustain the innovation, hence, the need for continuous support from various institutions. Since collaboration and partnership building between institutions has proved to be working effectively so far and is predicted to continue into the future – and may involve the strengthening of existing collaborations but also including new ones (e.g., Solomon Islands National University and Technical and Vocational Education Institution).

Second, targeting specific actors (e.g., highly motivated individual farmers) will be essential for rural interventions promoting SSA. Even though this model is a well-established notion with rural development initiatives, many institutions still overlook this implementation strategy for small-scale tilapia aquaculture (O'Garra, 2007). The findings presented in this chapter re-emphasise the need for and importance of considering this strategy for the small-scale tilapia aquaculture sector. Some practical ways to support this might be for institutions to conduct preliminary assessments (e.g., scoping studies, feasibility studies and value-chain analysis) to identify the right people to participate (i.e., those with genuine need). This can provide institutions with useful information on potential candidates to work with within communities.

Taken together, these findings can inform the ongoing development of small-scale tilapia aquaculture in Solomon Islands and the Pacific Islands region more broadly.

CHAPTER 5 SUMMARY: Roles, barriers & opportunities of small-scale tilapia aquaculture in Solomon Islands – perspectives from formal institutional actors

The limited per capita contribution of coastal fish species to food security in the Pacific Islands in the future calls for investment into other supplementary fish production sources. Small-scale tilapia aquaculture has been promoted as a potential fish production source. To date, little is known of the role of institutions in supporting the small-scale tilapia aquaculture sector in the Pacific Islands. Through semi-structured interviews with institutions supporting small-scale tilapia aquaculture development in Solomon Islands, I found the two primary roles played by the institutions included the provision of technical support to farmers and collaboration and partnership between institutions. Milestones achieved included increased technical knowledge and broader awareness of small-scale tilapia aquaculture (among farmers), and a more farmer-driven development approach (at the institutional level). Important lessons learned from engagement with farmers included the need to target the "right" farmers/beneficiaries for small-scale tilapia aquaculture, the understanding that geographical spread also influences the success of the sector, and the importance of consistent communication with farmers, the long-term financial commitment by institutions, and capacity building of technical staff. Two constraints for the sector were the slow growth of the current tilapia species and its limited market opportunities. This chapter showed the importance of institutions in supporting the small-scale tilapia aquaculture sector and pointed to a need for their continuous and sustained involvement in the future. Lastly, an improved species of tilapia to replace the current Mozambique tilapia will provide an opportunity to boost the small-scale tilapia aquaculture sector, thus, maximising its contribution to food security and livelihoods.

6. Chapter 6: Discussion

6.1. Introduction

Nearly two billion people are currently experiencing food insecurity globally (FAO et al., 2020). With declining capture fisheries production, aquaculture has been proposed to fill the fish supply-demand gap. In developing countries, the aquaculture sector is dominated by small-scale activities that are implemented to support livelihoods and improve food security. Empirical evidence to support the contributions of these SSA activities to livelihoods and food security, to date, remains inconclusive. While most empirical research on SSA and its contribution to livelihoods and food security comes from Asia and Africa, there has been limited research that explores this perspective in the Pacific Islands region.

Research presented in this thesis has aimed to understand the social dimensions of small-scale tilapia aquaculture development in the Pacific Islands region by exploring the case of Mozambique tilapia farming in Malaita Province, Solomon Islands. To do this, four research questions were proposed:

1) What social factors are influencing the adoption of small-scale tilapia aquaculture by tilapia farmers in Solomon Islands?
2) What contribution has small-scale tilapia aquaculture made to the livelihoods of tilapia farmers in Solomon Islands?
3) What contribution has small-scale tilapia aquaculture made towards household diets, relative to other ASFs consumed?
4) What are the roles, barriers, and opportunities for formal institutions in supporting the development of effective small-scale tilapia aquaculture in Solomon Islands?

By answering these research questions, this thesis provided important empirical evidence for policy and decision-makers to formulate appropriate policies, strategies, and interventions that will not only prioritise increased fish production but ensure such increased production translates tangibly onto improved livelihoods and food security of Pacific Islanders.

To address these research questions, household surveys, focus group discussions, and semi-structured interviews with individuals, households, groups of men and women, and staff from relevant organisations were conducted. Results showed that:

1) Socio-economic variables (e.g., age, subsistence level of households, and MSL)

influenced the adoption of small-scale tilapia aquaculture more than other contextual factors (e.g., communication channels and attributes of the innovation).

2) Small-scale Mozambique tilapia aquaculture contributed negligibly to livelihood outcomes (i.e., contribution to household food and income).
3) Small-scale Mozambique tilapia aquaculture also contributed minimally to the food security of households, with fresh marine fish accounting for a greater portion (in weight) of the diverse types of fish households consumed, while processed fish products were most consumed by households.
4) Institutions played important roles in driving the current development of the small-scale tilapia aquaculture sector in Solomon Islands.
5) The poor genetic quality of the Mozambique tilapia available in Solomon Islands was considered the main constraint to the widespread development of the tilapia aquaculture sector. Replacing it with a better performing species in aquaculture would be a positive step forward for the sector.

The key results are further deliberated in correspondence to each of the above-proposed research questions.

6.2. Social factors influencing the uptake of small-scale tilapia aquaculture in rural Solomon Islands.

The adoption of SSA innovations by rural farmers in developing countries is subjected to a range of enabling factors, which may include technological, institutional, environmental, social, and economic factors. In the second chapter of this thesis, socio-economic factors were shown to have influenced the adoption of small-scale tilapia aquaculture among tilapia farmers in Malaita Province. This particular finding is well supported by previous research, reaffirming the significance of socio-economic factors on SSA adoption and its potential to deliver outcomes among fish farmers (Diedrich et al., 2019; Mandima, 1995; Pollnac et al., 2019; Ruddle, 1993; Slater et al., 2013; Thomas, 1994; Wetengere, 2011).

The importance of considering the socio-economic contexts of tilapia farmers before the introduction of SSA interventions is a well-established argument. For example, studies by Pollnac (1978); Smith and Peterson (1982), and Thomas (1994) asserted that careful consideration of the socio-economic contexts of potential fish farmers is key to the success of SSA initiatives. The conclusions from these studies were drawn from experiences with SSA development in developing countries (e.g., African countries) where, despite numerous

investments to develop the sector in the past, attempts had failed because of the inadequate consideration of the socio-economic context of farmers. These failed attempts were evidenced by the limited expansion of SSA activities and little tangible impact on livelihoods and food security (Arthur et al., 2013; Brummett et al., 2008). More recent studies have continued to support these arguments for considering socio-economic factors across multiple developing country contexts, from Africa to Asia, and now in the Pacific Islands region (see Blythe et al., 2017; Diedrich et al., 2019; Morgan et al., 2016; Slater et al., 2013). Careful consideration of farmers' socio-economic contexts is important because it bears influence on their decision-making process, either to adopt or reject innovations (Rogers, 2003). As Ahmed and Toufique (2015, p. 2317) state: *"Even if biological, technological, and ecological conditions are favorable for aquaculture, it may fail if socio-economic factors are unfavorable…. Socio-economic issues are significant in decision-making".* This statement suggests that decisions by fish farmers on whether to adopt SSA initiatives or not are dependent on their socio-economic and cultural circumstances (Diedrich et al., 2019; Slater et al., 2013). This means that fish farmers without access to essential assets (e.g., land or water) and are financially stressed may find it difficult to adopt or practice SSA, even if the SSA initiative is attractive to them (e.g., a source of food or income) (Diedrich et al., 2019). This may also result in situations where, when external support (e.g., from projects) to SSA initiatives in rural areas are withdrawn, then long-term sustainability of the aquaculture activity becomes a challenge (Brummett et al., 2011; Pouomogne et al., 2010).

Socio-economic contexts also influence who benefits, and who is excluded from participating in SSA (Grivetti, 2019; Morgan et al., 2016; Pollnac, 1978; Ruddle, 1993). The notion of "elite-capture" illustrates this point, where instead of the poorest farmers benefiting tangibly from the activity, it is often the wealthier fish farmers who benefit more (Arthur et al., 2013; Belton & Little, 2011). Wealthier farmers are apt to benefit more from SSA because they are better positioned than poor farmers – due to their improved socio-economic status (e.g., in possession of various forms of assets), and capability (e.g., labour mobilisation, connections, and networks) – to participate effectively in SSA initiatives and subsequently capture greater benefits (Diedrich et al., 2019).

In the PICTs, the importance of considering the socio-economic context where SSA initiatives are being introduced is also emphasised (Amos et al., 2014; Mather & Nandlal, 2013; Ponia, 2010). Research findings presented in this thesis also contribute to this emphasis and asserts

that current SSA initiatives in the Pacific Islands region must consider the socio-economic context of fish farmers to ensure the sector makes a significant contribution to rural livelihoods and food security. There are practical implications (e.g., lack of longevity of project activities) if the socio-economic and cultural context of fish farmers are not clearly understood and considered (Govan, 2011; O'Garra, 2007; Vandenberg et al., 2021). Additionally, there is often a lack of scoping and feasibility studies conducted by external agencies to really understand the socio-economic and cultural context of potential fish farmers before implementing SSA initiatives (O'Garra, 2007; Vandenberg et al., 2021). Even if such studies were conducted prior to project implementation they often fail to consider the complex nature of livelihoods of rural Pacific Islanders – evident through land tenure systems, resource utilisation, subsistence lifestyle, and social institutions (e.g., kinship, extended family) (Eriksson et al., 2020). This often led to livelihood initiatives that only had minimal tangible impact on people's livelihood or may work well in one context but not in another. In other words, these ("failed" livelihood initiatives) are often the result of a mismatch between project or donor priorities and community needs (ibid). For small-scale tilapia aquaculture in Solomon Islands, this study found that age, subsistence level of households, and MSL was likely to influence its adoption among fish farmers. Older farmers from less-subsistence households, but with a much more basic MSL than other non-subsistence households were most likely to adopt tilapia farming.

6.3. Small-scale tilapia aquaculture's limited contribution to food security and livelihood outcomes

In most developing countries, SSA initiatives have been implemented to off-set diminishing wild-capture fisheries production and provide a source of cheap and accessible ASF to the poor and food-insecure (Kobayashi et al., 2015). In Chapters 3 and 4 of this thesis, the analysis revealed that current small-scale tilapia aquaculture in Malaita Province contributed minimally to the livelihood and food security of tilapia farming households. The analysis illustrated that many (40%) tilapia farmers were not satisfied with the impact of their tilapia farming activities. In addition to this, for the few tilapia farmers who traded their fish, income from this source only contributed 0.002% to 0.5% to their total weekly income. Small-scale tilapia aquaculture, therefore, contributed negligibly in comparison to the other income generating activities that households were involved in. In terms of income generation, Pouomogne et al. (2010) also found a similar result in Cameroon, whereby fish farming accounted for only 0.67% of the total income of households practising fish farming. Findings

presented in this thesis also contrast markedly to cases in Asia, for example in Bangladesh, where estimates of income from carp-based fish farming have ranged from 7-11% of household income of fish farming households (E-Jahan et al., 2010; Karim and Little, 2018). These studies suggest that contributions from fish farming in Bangladesh are at least twenty times what the current contribution is to the weekly income of tilapia farmers in Malaita Province. In the Pacific Islands region, such supplementary livelihoods as fish farming which are introduced by external agents, are perceived by most rural fish farmers as a means to diversify their livelihood – notably their income-generating opportunities (Eriksson et al., 2020; Govan, 2011; O'Garra, 2007). Hence, when the income generative capability of such supplementary livelihoods are not forthcoming, long-term sustainability issues and abandonment of activities become common, as fish farmers shift their focus to more economically viable alternatives (Harohau et al., 2016).

In addition to its negligible contribution to income, small-scale tilapia aquaculture also contributed minimally to fish consumption in households interviewed for this research. The results revealed that 82% of the households consumed processed fish products, 49% consumed fresh marine fish, while only 3% of households consumed tilapia. Moreover, in-terms of the weight of fish consumed, marine fish accounted for 71.4%, processed fish products 25.9%, freshwater species 2.6%, while tilapia only 0.1%. This implies the current form of small-scale tilapia aquaculture will unlikely complement coastal fisheries production meaningfully and address food security. Undoubtedly, it will take some time for locals to develop a more favourable impression toward tilapia as food before they start consuming it like other popular fish foods such as marine fish and processed fish products. Grivetti (2019) argued that it is naïve of institutions to think that people will instantly jump to consuming foods they are not familiar with, even if they have access to them. Yet, in Solomon Islands, people already have a tradition of eating wild-caught fish from fresh, brackish and marine environments (Gereva, 2014). Hence, a transition from dominantly consuming marine fish to tilapia is possible and can be aided by institutional investments promoting its consumption and health benefits among local communities.

Marine fish will undoubtedly maintain its place as the most important non-processed fish type consumed by rural households in Solomon Islands. This is supported by published literature that highlights the dominance of fish from capture fisheries in household diets globally, but also across the Pacific Islands region (Charlton et al., 2016; FAO, 2020). In their study of

household fish consumption among rural households in Solomon Islands, Cleasby et al. (2014); Horsey et al. (2019) and Albert et al. (2020) found fresh marine fish were consumed more than other fish and ASFs. Like other PICTs, this trend in fish consumption signifies the vital role of marine fish as the preferred ASF in the diets of Solomon Islanders. Yet, ever-increasing human populations in Solomon Islands is resulting in unsustainable harvesting levels of coastal marine fish (Weeratunge et al., 2011). This is coupled with the exacerbated impacts of climate change imminent in the Pacific Island region (Asian Development Bank, 2014; Pratchett et al., 2011). Investments and efforts by the local government and development organisations, therefore, need to strengthen the management of the coastal fisheries sector to ensure continuous and sustainable marine fish supply into the future (Cohen et al., 2019). Alternatively, the seemingly widespread consumption of processed fish products evident in this study shows that these products have an important role in household food security. Although respondents did not mention the reasons for their increased consumption of processed fish products, it is possible that the factors mentioned by Jones et al. (2014b) such as the product's cost-effectiveness, accessibility and long shelf life hold true and are relevant. The increasing trend of processed fish product consumption is validated by Bell et al. (2019) whereby Solomon Islands was ranked only second to Fiji in the consumption of processed fish products.

Hence, while support for fisheries and aquaculture development in developing countries to address the widespread malnutrition is growing (Thilsted et al., 2016), empirical evidence on their tangible contributions to food security and livelihoods is necessary. Yet, this current study showed that in small island developing states like Solomon Islands, the lacklustre performance of the current small-scale tilapia aquaculture in complementing coastal fisheries production implies expectations of positive contributions from the sector, to date, should be moderate. Hence, in chapters 3 and 4, I posed several important questions and thoughts on the role of small-scale tilapia aquaculture as a complementary fish production source and its contributions to rural livelihoods and food security, in Solomon Islands (and other PICTs). These questions included: is investment in small-scale tilapia aquaculture a reasonable choice, and should it continue (Scholtens & Bavinck, 2017)? Or should the focus and efforts of investments be diverted to developing other potential commodities (e.g., seaweed) for SSA instead, that can support livelihoods through income generation? If there is a preference for looking into new species for SSA, then farming of small indigenous species might first, or simultaneously, be examined given that challenges with developing feeds for exotic species can mean aquaculture investments are in fact not sustainable once development aid has ceased. Or would it be more viable to focus on improved management of wild fisheries, or

alternative livelihood/food security solutions instead? Furthermore, this study showed that most households were relying on and preferring processed fish products as a complementary source of fish, which suggests that this animal-sourced food may be preferred, affordable, and perhaps a more worthwhile investment for addressing the forecast fish-for-food gap. This study, therefore, contends that across PICTs, targeting and addressing food security (through considering the differential nutritional needs and local food preferences) and rural livelihood needs will be critical to the success of any fish production-based strategy (e.g., tilapia aquaculture), and not necessarily just increasing fish production and assuming it will translate tangibly to food security and livelihood needs.

6.4. Barriers and opportunities to small-scale tilapia aquaculture development, as perceived by formal institutions.

The support of institutions to SSA development in developing countries is crucial as it can provide the right environment for SSA initiatives to progress and deliver tangible outcomes. In Chapter 5, three institutions were interviewed. Results from these interviews detailed the biophysical limitations of the Mozambique tilapia species and that the absence of a market for tilapia were the two most highlighted barriers to small-scale tilapia aquaculture development in Malaita Province of Solomon Islands.

First, low-quality fingerlings are a major constraint to SSA development as it hampers technical efficiency and operation of fish farms and, therefore, their eventual productivity (Alam et al., 2012; Limuwa et al., 2018; Phuong & Oanh, 2010; Pouomogne et al., 2010). This can lead to producing fish that is of low value with limited demand from local consumers. This realisation has prompted a number of PICTs (e.g., Fiji, Vanuatu, Papua New Guinea, etc.) to now shift their focus to farming Nile tilapia (and GIFT[13] tilapia). In Solomon Islands, Mozambique tilapia is the only tilapia species present and has been established to be of poor genetic quality – as a result of a series of generational mixed breeding from its original broodstock (Macaranas et al., 1997; Pickering, 2010). The Mozambique species also possess undesirable biological characteristics (Gupta & Acosta, 2004; Russell et al., 2012) – rendering it not viable for aquaculture. Attributes, such as slow growth, early maturity, and high fecundity can lead to stunted growth which is undesirable for small-scale aquaculture (Russell

[13] GIFT stands for **G**enetically **I**mproved **F**armed **T**ilapia and is a genetically improved strain of the Nile tilapia (*Oreochromis niloticus*) (Modadugu & Acosta, 2004).

et al., 2012). However, in Solomon Islands it was promoted for small-scale aquaculture because it is the only tilapia species locally available, and because since its introduction in the 1950s farmers have already been farming it in rudimentary forms, in the absence of a more viable tilapia or fish species. In the study site, although Mozambique tilapia ponds can produce reasonably large biomass of small fish (Harohau et al., 2016), the small-sized fish are not favoured by many local tilapia farmers and consumers, which not only hinders household consumption of tilapia but also opportunities for sales at markets. Having a market to sell the aquaculture product is important for generating income and thus supporting livelihoods and food security (Asiedu et al., 2016; Duc, 2009; Edwards, 2000; Phuong & Oanh, 2010). In the Pacific Islands region, O'Garra (2007) and Govan (2011) also stressed that limited access to markets was one of the major constraints to the long-term sustainability of introduced livelihood projects. It is therefore imperative that people must perceive a market for the output or product of a project before it can be widely taken up and successfully deliver positive outcomes.

In other developing countries globally, Mozambique tilapia is no longer considered for aquaculture purposes (Modadugu & Acosta, 2004; Russell et al., 2012). Subsequently, MFMR needs to replace Mozambique tilapia with a better performing species such as Nile tilapia or the GIFT strain (Ministry of Fisheries and Marine Resources, 2009, 2010, 2018). Such a step would be a positive development for the small-scale tilapia aquaculture sector in Solomon Islands and following the footsteps of Vanuatu, Fiji, Papua New Guinea which already farm the improved Nile species (Lal & Foscarini, 1990; Pickering, 2010; Pickering, 2015; Smith, 2007). As previously mentioned, whatever species being farmed, to make small-scale tilapia aquaculture a viable enterprise for rural farmers and a major contributor to livelihoods and food security, its wider acceptability as a food fish in the Solomon Islands' context must be firstly ensured.

6.5. Limitations and future directions for research

While this thesis was able to provide some understanding of the social dimensions of small-scale tilapia aquaculture development in Solomon Islands, there were identified caveats that future research can build on. In Chapter 2, social factors that are influencing the adoption of small-scale tilapia aquaculture in Malaita Province were explored. Given the scope of the research and the theoretical framing, three broad groups of variables (i.e., socio-economic, communication channels and attributes of innovation variables) were selected. However, these

three variables may not be inclusive of all possible variables likely to influence the adoption of small-scale tilapia aquaculture. For example, looking beyond the DOI model used, there may be other variables that might influence tilapia farmers' decision to adopt small-scale tilapia aquaculture (e.g., institutional or taste preference). Future research could explore the taste preference of locals of the various types of fish being consumed and how this may affect the wider acceptability of tilapia as a food fish, and hence, its adoption.

In Chapter 3, I mentioned that the temporal nature of this study also presented a limitation in trying to establish a clearer picture of the benefits of small-scale tilapia aquaculture. This is because this study was conducted several years after adoption decisions were made by tilapia farmers; thus, benefits arising after immediate implementation may not have been captured. Memory recall of tilapia farmers in terms of the benefits sourced from their small-scale tilapia aquaculture (e.g., tilapia consumption and income earned) may also have differed during the first few years after taking up the activity. Future research could employ a more longitudinal study to observe and capture all benefits from small-scale tilapia aquaculture that may accrue over time (Thomas, 1994).

In this thesis, the focus has been on small-scale tilapia aquaculture as an SSA activity in Solomon Islands. The unfavourable characteristics of the Mozambique tilapia, however, puts the current small-scale tilapia aquaculture in a rather unfavourable position as an SSA initiative that can make a useful contribution to livelihoods and food security. Yet, SSA of other species may hold more potential in Solomon Islands and the Pacific Islands region overall (e.g., endemic species in mariculture) (Brugere et al., 2021). Consequently, future research should investigate the potential of other fish species (e.g., endemic species) in SSA.

6.6. Conclusion

It has been established that the ability of SSA aquaculture initiatives to deliver tangible outcomes for livelihoods and food security are contingent upon multiple factors. Furthermore, while most studies on SSA and its contribution to livelihoods and food security are fixated on experiences from Asia and Africa, there is a paucity of empirical evidence on this originating from the Pacific Islands region. Hence, the overall objectives of this thesis were to:

1) Identify social factors influencing the uptake of small-scale tilapia aquaculture among rural tilapia farmers in Malaita Province.
2) Identify contributions of small-scale tilapia aquaculture to their livelihoods and food

security.

3) Explore the roles, barriers and opportunities for small-scale tilapia aquaculture as perceived by relevant institutions.

Socio-economic factors were found to influence the adoption of small-scale tilapia aquaculture amongst tilapia farmers with small-scale tilapia aquaculture providing minimal contributions to livelihood outcomes and household fish consumption. Small-scale tilapia aquaculture may have the potential to contribute to livelihoods and food security in Solomon Islands, but only when certain conditions are met. It is therefore imperative that interventions must consider the context-specific socio-economic factors to ensure their wider adoption and ability to deliver outcomes. Furthermore, issues surrounding the wider acceptability of tilapia, in a context where marine fish is traditionally consumed, is also important to consider. Only when people are willing and able to widely consume tilapia can tilapia play a significant role toward livelihoods and food security.

As marine fish remains importantly consumed in the local context, effective coastal fisheries management will be essential. Further exploration of the role of processed fish products in food security should also be considered.

Finally, institutions supporting the development of the small-scale tilapia aquaculture in Solomon Islands identified the poor biological attributes of Mozambique tilapia for aquaculture as the major constraint. Current plans and efforts by MFMR to introduce Nile tilapia will indeed boost the sector going forward, as it will prevent the current biophysical bottlenecks faced with the current Mozambique species.

In extrapolating the findings of this thesis beyond Solomon Islands (i.e., other PICTs and developing countries), this research highlights the need to engage more closely with the socio-economic conditions conducive for small-scale tilapia aquaculture's uptake by tilapia farmers and its ability to deliver outcomes for livelihoods and food security. Research presented in this thesis also brings into question the notion of SSA as a panacea for addressing livelihoods and food security. While it may be obvious that SSA in Asian countries is relatively successful, empirical evidence in Africa (Britz & Rouhani, 2004; Brummett et al., 2008) and this study do not show similar success stories from SSA. This thesis clearly illustrates that the success of SSA in improving livelihoods and food security varies across diverse contexts and are highly dependent on the fish species promoted.

Reference

Abbaspour, N., Hurrell, R., & Kelishadi, R. (2014). Review on iron and its importance for human health. *Journal of research in medical sciences : the official journal of Isfahan University of Medical Sciences, 19*(2), 164-174. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3999603/

Abdullah, A. N., Myers, B., Stacey, N., Zander, K. K., & Garnett, S. T. (2016). The impact of the expansion of shrimp aquaculture on livelihoods in coastal Bangladesh. *Environment, Development and Sustainability*, 1-22. doi:10.1007/s10668-016-9824-5

Adams, T., Bell, J., & Labrosse, P. (2001). Current status of aquaculture in the Pacific Islands.

Adesina, A. A., Mbila, D., Nkamleu, G. B., & Endamana, D. (2000). Econometric analysis of the determinants of adoption of alley farming by farmers in the forest zone of southwest Cameroon. *Agriculture, Ecosystems & Environment, 80*(3), 255-265. doi:https://doi.org/10.1016/S0167-8809(00)00152-3

Adolwa, I. S., Okoth, P. F., Mulwa, R. M., Esilaba, A. O., Mairura, F. S., & Nambiro, E. (2012). Analysis of Communication and Dissemination Channels Influencing the Adoption of Integrated Soil Fertility Management in Western Kenya. *The Journal of Agricultural Education and Extension, 18*(1), 71-86. doi:10.1080/1389224X.2012.638782

Ahmed, B. N., & Waibel, H. (2019). The role of homestead fish ponds for household nutrition security in Bangladesh. *Food Security*. doi:10.1007/s12571-019-00947-6

Ahmed, M., & Lorica, M. H. (2002). Improving developing country food security through aquaculture development—lessons from Asia. *Food Policy, 27*(2), 125-141. doi:http://dx.doi.org/10.1016/S0306-9192(02)00007-6

Ahmed, N. (2009). The Sustainable Livelihoods Approach to the Development of Fish Farming in Rural Bangladesh. *Journal of International Farm Management, 4*(4), 1-18. Retrieved from http://www.ingentaconnect.com/content/iagrm/jifm/2009/00000004/00000004/art00001

Ahmed, N., Allison, E. H., & Muir, J. F. (2008a). Using the Sustainable Livelihoods Framework to Identify Constraints and Opportunities to the Development of Freshwater Prawn Farming in Southwest Bangladesh. *Journal of the World Aquaculture Society, 39*(5), 598-611. doi:10.1111/j.1749-7345.2008.00198.x

Ahmed, N., & Toufique, K. A. (2015). Greening the blue revolution of small-scale freshwater aquaculture in Mymensingh, Bangladesh. *Aquaculture Research, 46*(10), 2305-2322. doi:10.1111/are.12390

Ahmed, N., Young, J. A., Dey, M. M., & Muir, J. F. (2012). From production to consumption: a case study of tilapia marketing systems in Bangladesh. *Aquaculture International, 20*(1), 51-70. doi:10.1007/s10499-011-9441-0

Ahmed, U. I., Ying, L., Bashir, M. K., Abid, M., & Zulfiqar, F. (2017). Status and determinants of small farming households' food security and role of market access in enhancing food security in rural Pakistan. *PLoS ONE, 12*(10), e0185466. doi:10.1371/journal.pone.0185466

Akombi, B. J., Agho, K. E., Hall, J. J., Merom, D., Astell-Burt, T., & Renzaho, A. M. N. (2017). Stunting and severe stunting among children under-5 years in Nigeria: A multilevel analysis. *BMC Pediatrics, 17*(1), 15. doi:10.1186/s12887-016-0770-z

Akpabio, I. A., & Inyang, E. B. (2007). Major constraints affecting aquaculture development in Akwa Ibom State, Nigeria. *African Journal of Aquatic Science, 32*(1), 45-50. doi:10.2989/AJAS.2007.32.1.7.144

Akudugu, M. A., Guo, E., & Dadzie, S. K. (2012). Adoption of modern agricultural production technologies by farm households in Ghana: What factors influence their decisions. *Journal of Biology, Agriculture and HealthCare*.

Alam, M. F., Khan, M. A., & Huq, A. S. M. A. (2012). Technical efficiency in tilapia farming

of Bangladesh: a stochastic frontier production approach. *Aquaculture International, 20*(4), 619-634. doi:10.1007/s10499-011-9491-3
Albert, J., Bogard, J., Siota, F., McCarter, J., Diatalau, S., Maelaua, J., Brewer, T., & Andrew, N. (2020). Malnutrition in rural Solomon Islands: An analysis of the problem and its drivers. *Maternal & Child Nutrition, n/a*(n/a), e12921. doi:10.1111/mcn.12921
Albert, J. A., Beare, D., Schwarz, A.-M., Albert, S., Warren, R., Teri, J., Siota, F., & Andrew, N. L. (2014). The Contribution of Nearshore Fish Aggregating Devices (FADs) to Food Security and Livelihoods in Solomon Islands. *PLoS ONE, 9*(12), e115386. doi:10.1371/journal.pone.0115386
Albert, S., Aswani, S., Fisher, P. L., & Albert, J. (2015). Keeping Food on the Table: Human Responses and Changing Coastal Fisheries in Solomon Islands. *PLoS ONE, 10*(7), e0130800. doi:10.1371/journal.pone.0130800
Aldwell, K., Caillaud, C., Galy, O., Frayon, S., & Allman-Farinelli, M. (2018). Tackling the Consumption of High Sugar Products among Children and Adolescents in the Pacific Islands: Implications for Future Research. *Healthcare, 6*(3), 81. Retrieved from http://www.mdpi.com/2227-9032/6/3/81
Allen, B., Bourke, R. M., & Gibson, J. (2005). Poor rural places in Papua New Guinea. *Asia Pacific Viewpoint, 46*(2), 201-217. doi:https://doi.org/10.1111/j.1467-8373.2005.00274.x
Allison, E., Béné, C., & Andrew, N. L. (2011). Poverty reduction as a means to enhance resilience in small-scale fisheries. In R. S. Pomeroy, Andrew, N. L. (Ed.), *Small-Scale Fisheries Management: Frameworks and Approaches for the Developing World* (pp. 216-237). https://www.cabi.org/cabebooks/ebook/20113041422.
Amos, M., Garcia, R., Pickering, T., & Jimmy, R. (2014). *Study on the Potential of Aquaculture in the Pacific*. Retrieved from https://brusselsbriefings.files.wordpress.com/2013/07/study-on-the-potential-of-aquaculture-in-the-pacific.pdf:
Andersen, A., Thilsted, S., & Schwarz, A. (2013). *Food and nutrition security in Solomon Islands*. Retrieved from http://aquaticcommons.org/id/eprint/11081
Andrew, N. L., Bright, P., de la Rua, L., Teoh, S. J., & Vickers, M. (2019). Coastal proximity of populations in 22 Pacific Island Countries and Territories. *PLoS ONE, 14*(9), e0223249. doi:10.1371/journal.pone.0223249
Anon. (2015). *Fisheries Management Act 2015*. https://www.ilo.org/dyn/natlex/natlex4.detail?p_lang=en&p_isn=102535&p_count=1&p_classification=19
Arthur, R., Bene, C., Leschen, W., & Little, D. (2013). *Fisheries and aquaculture and their potential roles in development: an assessment of the current evidence*. Retrieved from https://www.gov.uk/dfid-research-outputs/fisheries-and-aquaculture-and-their-potential-roles-in-development-an-assessment-of-the-current-evidence:
Asfaw, D., & Neka, M. (2017). Factors affecting adoption of soil and water conservation practices: The case of Wereillu Woreda (District), South Wollo Zone, Amhara Region, Ethiopia. *International Soil and Water Conservation Research, 5*(4), 273-279. doi:https://doi.org/10.1016/j.iswcr.2017.10.002
Asian Development Bank. (2005). *An evaluation of small-scale freshwater rural aquaculture development for poverty reduction*. Retrieved from http://hdl.handle.net/11540/4727:
Asian Development Bank. (2014). *State of the Coral Triangle: Solomon Islands*. Retrieved from http://www.adb.org/publications/state-coral-triangle-solomon-islands
Asiedu, B., Failler, P., & Beyens, Y. (2016). Enhancing aquaculture development: mapping the tilapia aquaculture value chain in Ghana. *Reviews in Aquaculture, 8*(4), 394-402. doi:10.1111/raq.12103
AUC-NEPAD. (2014). *The Policy Framework and Reform Strategy for Fisheries and Aquaculture in Africa*. Retrieved from https://au.int/en/documents/20140910:

Baltenweck, I., & Staal, S. (2007). Beyond One-Size-Fits-All: Differentiating Market Access Measures for Commodity Systems in the Kenyan Highlands. *Journal of Agricultural Economics, 58*(3), 536-548. doi:doi:10.1111/j.1477-9552.2007.00129.x

Bandiera, O. (2006). Social Networks and Technology Adoption in Northern Mozambique. *The Economic journal (London), 116*(514), 869-902. doi:10.1111/j.1468-0297.2006.01115.x

Barbier, J., Jimmy, R., & Nandlal, S. (2010). *Monoculture of the freshwater prawn, Macrobrachium lar, in Vanuatu and integrated prawn-taro farming in Wallis & Futuna*.

Barnes, M. L., Lynham, J., Kalberg, K., & Leung, P. (2016). Social networks and environmental outcomes. *Proceedings of the National Academy of Sciences of the United States of America, 113*(23), 6466-6471. doi:10.1073/pnas.1523245113

Bartley, D. M., De Graaf, G. J., Valbo-Jørgensen, J., & Marmulla, G. (2015). Inland capture fisheries: status and data issues. *Fisheries Management and Ecology, 22*(1), 71-77. doi:10.1111/fme.12104

Baticados, D. B., Agbayani, R. F., & Quinitio, E. T. (2014). Community-Based Technology Transfer in Rural Aquaculture: The Case of Mudcrab Scylla serrata Nursery in Ponds in Northern Samar, Central Philippines. *AMBIO, 43*(8), 1047-1058. doi:10.1007/s13280-014-0528-5

Batty, M. (1987) Eel fishing pilot project in Solomon Islands. In. Accessed from https://coastfish.spc.int/en/publications/bulletins/fisheries-newsletter.

Belhabib, D., Sumaila, U. R., & Le Billon, P. (2019). The fisheries of Africa: Exploitation, policy, and maritime security trends. *Marine Policy, 101*, 80-92. doi:https://doi.org/10.1016/j.marpol.2018.12.021

Bell, J. D., Albert, J., Andréfouët, S., Andrew, N. L., Blanc, M., Bright, P., Brogan, D., Campbell, B., Govan, H., Hampton, J., Hanich, Q., Harley, S., Jorari, A., Lincoln Smith, M., Pontifex, S., Sharp, M. K., Sokimi, W., & Webb, A. (2015a). Optimising the use of nearshore fish aggregating devices for food security in the Pacific Islands. *Marine Policy, 56*, 98-105. doi:http://dx.doi.org/10.1016/j.marpol.2015.02.010

Bell, J. D., Allain, V., Allison, E. H., Andréfouët, S., Andrew, N. L., Batty, M. J., Blanc, M., Dambacher, J. M., Hampton, J., Hanich, Q., Harley, S., Lorrain, A., McCoy, M., McTurk, N., Nicol, S., Pilling, G., Point, D., Sharp, M. K., Vivili, P., & Williams, P. (2015b). Diversifying the use of tuna to improve food security and public health in Pacific Island countries and territories. *Marine Policy, 51*, 584-591. doi:http://dx.doi.org/10.1016/j.marpol.2014.10.005

Bell, J. D., Ganachaud, A., Gehrke, P. C., Griffiths, S. P., Hobday, A. J., Hoegh-Guldberg, O., Johnson, J. E., Le Borgne, R., Lehodey, P., Lough, J. M., Matear, R. J., Pickering, T. D., Pratchett, M. S., Gupta, A. S., Senina, I., & Waycott, M. (2013). Mixed responses of tropical Pacific fisheries and aquaculture to climate change. *Nature Climate Change, 3*(6), 591-599. doi:10.1038/nclimate1838

Bell, J. D., Kronen, M., Vunisea, A., Nash, W. J., Keeble, G., Demmke, A., Pontifex, S., & Andréfouët, S. (2009). Planning the use of fish for food security in the Pacific. *Marine Policy, 33*(1), 64-76. doi:http://dx.doi.org/10.1016/j.marpol.2008.04.002

Bell, J. D., Sharp, M. K., Havice, E., Batty, M., Charlton, K. E., Russell, J., Adams, W., Azmi, K., Romeo, A., Wabnitz, C. C. C., Andrew, N. L., Rodwell, L., Gu'urau, S., & Gillett, R. (2019). Realising the food security benefits of canned fish for Pacific Island countries. *Marine Policy, 100*, 183-191. doi:https://doi.org/10.1016/j.marpol.2018.10.034

Belton, B., Karim, M., Thilsted, S. H., Murshed-E-Jahan, K., Collis, W., & Phillips, M. (2011b). Review of aquaculture and fish consumption in Bangladesh. In *Studies and Reviews 2011-53* (pp. 71). Penang, Malaysia: The WorldFish Center.

Belton, B., & Little, D. C. (2011). Immanent and Interventionist Inland Asian Aquaculture Development and its Outcomes. *Development Policy Review, 29*(4), 459-484.

doi:10.1111/j.1467-7679.2011.00542.x
Belton, B., Little, D. C., & Sinh, L. X. (2011a). The social relations of catfish production in Vietnam. *Geoforum, 42*(5), 567-577. doi:https://doi.org/10.1016/j.geoforum.2011.02.008
Belton, B., & Thilsted, S. H. (2014). Fisheries in transition: Food and nutrition security implications for the global South. *Global Food Security, 3*(1), 59-66. doi:http://dx.doi.org/10.1016/j.gfs.2013.10.001
Belton, B., van Asseldonk, I. J. M., & Thilsted, S. H. (2014). Faltering fisheries and ascendant aquaculture: Implications for food and nutrition security in Bangladesh. *Food Policy, 44*, 77-87. doi:http://dx.doi.org/10.1016/j.foodpol.2013.11.003
Béné, C., Arthur, R., Norbury, H., Allison, E. H., Beveridge, M., Bush, S., Campling, L., Leschen, W., Little, D., Squires, D., Thilsted, S. H., Troell, M., & Williams, M. (2016). Contribution of Fisheries and Aquaculture to Food Security and Poverty Reduction: Assessing the Current Evidence. *World Development, 79*, 177-196. doi:http://dx.doi.org/10.1016/j.worlddev.2015.11.007
Béné, C., Barange, M., Subasinghe, R., Pinstrup-Andersen, P., Merino, G., Hemre, G.-I., & Williams, M. (2015). Feeding 9 billion by 2050 – Putting fish back on the menu. *Food Security, 7*(2), 261-274. doi:10.1007/s12571-015-0427-z
Beveridge, M. C. M., Thilsted, S. H., Phillips, M. J., Metian, M., Troell, M., & Hall, S. J. (2013). Meeting the food and nutrition needs of the poor: the role of fish and the opportunities and challenges emerging from the rise of aquaculturea. *Journal of Fish Biology, 83*(4), 1067-1084. doi:10.1111/jfb.12187
Bhujel, R. C. (2009). *Small-scale aquaculture: Global and national perspectives.* Paper presented at the Small-Scale Aquaculture for Increasing Resilience of Rural Livelihoods in Nepal, Kathmandu, Nepal.
Blythe, J., Sulu, R., Harohau, D., Weeks, R., Schwarz, A.-M., Mills, D., & Phillips, M. (2017). Social Dynamics Shaping the Diffusion of Sustainable Aquaculture Innovations in the Solomon Islands. *Sustainability, 9*(1), 126. Retrieved from http://www.mdpi.com/2071-1050/9/1/126
Blythe, J. L. (2013). Social-ecological analysis of integrated agriculture-aquaculture systems in Dedza, Malawi. *Environment, Development and Sustainability, 15*(4), 1143-1155. doi:10.1007/s10668-012-9429-6
Bogard, J. R., Chowdhury, S. K., Rizwan, A. A. M., & Thilsted, S. H. (2017b). Measuring Fish Consumption: A visual guide to estimating portion sizes. In WorldFish (Ed.). Dhaka, Bangladesh: WorldFish.
Bogard, J. R., Farook, S., Marks, G. C., Waid, J., Belton, B., Ali, M., Toufique, K., Mamun, A., & Thilsted, S. H. (2017a). Higher fish but lower micronutrient intakes: Temporal changes in fish consumption from capture fisheries and aquaculture in Bangladesh. *PLoS ONE, 12*(4), e0175098. doi:10.1371/journal.pone.0175098
Bogard, J. R., Marks, G. C., Mamun, A., & Thilsted, S. H. (2016). Non-farmed fish contribute to greater micronutrient intakes than farmed fish: results from an intra-household survey in rural Bangladesh. *Public Health Nutrition, 20*(4), 702-711. doi:10.1017/S1368980016002615
Brewer, T. D., Cinner, J. E., Fisher, R., Green, A., & Wilson, S. K. (2012). Market access, population density, and socioeconomic development explain diversity and functional group biomass of coral reef fish assemblages. *Global Environmental Change, 22*(2), 399-406. doi:http://dx.doi.org/10.1016/j.gloenvcha.2012.01.006
Brewer, T. D., Cinner, J. E., Green, A., & Pandolfi, J. M. (2009). Thresholds and multiple scale interaction of environment, resource use, and market proximity on reef fishery resources in the Solomon Islands. *Biological Conservation, 142*(8), 1797-1807. doi:https://doi.org/10.1016/j.biocon.2009.03.021
Britz, P. J., & Rouhani, Q. A. (2004). *Contribution of Aquaculture to Rural Livelihoods in*

South Africa: A Baseline Study Retrieved from Republic of South Africa:
Brugere, C., Troell, M., & Eriksson, H. (2021). More than fish: Policy coherence and benefit sharing as necessary conditions for equitable aquaculture development. *Marine Policy, 123*, 104271. doi:https://doi.org/10.1016/j.marpol.2020.104271
Brummett, R. E., Lazard, J., & Moehl, J. (2008). African aquaculture: Realizing the potential. *Food Policy, 33*(5), 371-385. doi:10.1016/j.foodpol.2008.01.005
Bueno, P. B. (2008). Strengthening sustainable development of aquaculture in Southeast Asia: Interventions and strategies to enhance the multiple roles of aquaculture in rural development. In: Secretariat, Southeast Asian Fisheries Development Center.
Calder, P. C., & Yaqoob, P. (2009). Omega-3 polyunsaturated fatty acids and human health outcomes. *BioFactors, 35*(3), 266-272. doi:10.1002/biof.42
Castañeda, A., Doan, D., Newhouse, D., Nguyen, M. C., Uematsu, H., & Azevedo, J. P. (2018). A New Profile of the Global Poor. *World Development, 101*, 250-267. doi:https://doi.org/10.1016/j.worlddev.2017.08.002
Castine, S. A., Bogard, J. R., Barman, B. K., Karim, M., Mokarrom Hossain, M., Kunda, M., Mahfuzul Haque, A. B. M., Phillips, M. J., & Thilsted, S. H. (2017). Homestead pond polyculture can improve access to nutritious small fish. *Food Security, 9*(4), 785-801. doi:10.1007/s12571-017-0699-6
Chambers, R., & Conway, G. (1992). *Sustainable rural livelihoods: Practical concepts for the 21st century*. Brighton: Institute of Development Studies
Charlton, K. E., Russell, J., Gorman, E., Hanich, Q., Delisle, A., Campbell, B., & Bell, J. (2016). Fish, food security and health in Pacific Island countries and territories: a systematic literature review. *BMC Public Health, 16*. doi:http://dx.doi.org/10.1186/s12889-016-2953-9
Chaves, W. A., Wilkie, D. S., Monroe, M. C., & Sieving, K. E. (2017). Market access and wild meat consumption in the central Amazon, Brazil. *Biological Conservation, 212*, 240-248. doi:http://dx.doi.org/10.1016/j.biocon.2017.06.013
Cleasby, N., Schwarz, A.-M., Phillips, M., Paul, C., Pant, J., Oeta, J., Pickering, T., Meloty, A., Laumani, M., & Kori, M. (2014). The socio-economic context for improving food security through land based aquaculture in Solomon Islands: A peri-urban case study. *Marine Policy, 45*, 89-97. doi:http://dx.doi.org/10.1016/j.marpol.2013.11.015
Coates, D. (1997). *Fish stocking activities undertaken by the Sepik River Fish Stock Enhancement Project (1987-1993) and the FISHAID Project (1993-1997)*. Retrieved from http://www.fao.org/3/bo809e/bo809e.pdf:
Cohen, P., Evans, L., & Govan, H. (2015). Community-Based, Co-management for Governing Small-Scale Fisheries of the Pacific: A Solomon Islands' Case Study. In S. Jentoft & R. Chuenpagdee (Eds.), *Interactive Governance for Small-Scale Fisheries: Global Reflections* (pp. 39-59). Switzerland: Springer International Publishing.
Cohen, P. J., Allison, E. H., Andrew, N. L., Cinner, J., Evans, L. S., Fabinyi, M., Garces, L. R., Hall, S. J., Hicks, C. C., Hughes, T. P., Jentoft, S., Mills, D. J., Masu, R., Mbaru, E. K., & Ratner, B. D. (2019). Securing a Just Space for Small-Scale Fisheries in the Blue Economy. *Frontiers in Marine Science, 6*(171). doi:10.3389/fmars.2019.00171
Cohen, P. J., & Foale, S. J. (2013). Sustaining small-scale fisheries with periodically harvested marine reserves. *Marine Policy, 37*(Supplement C), 278-287. doi:https://doi.org/10.1016/j.marpol.2012.05.010
Connell, J. (1984). Islands under Pressure: Population Growth and Urbanization in the South Pacific. *AMBIO, 13*(5/6), 306-312. Retrieved from http://www.jstor.org.elibrary.jcu.edu.au/stable/4313063
Connell, J. (2015). Food security in the island Pacific: Is Micronesia as far away as ever? *Regional Environmental Change, 15*(7), 1299-1311. doi:10.1007/s10113-014-0696-7
Creswell, J. W., & Poth, C. N. (2016). *Qualitative inquiry and research design: Choosing among five approaches*: Sage publications.

Curry, G. N., Koczberski, G., Lummani, J., Nailina, R., Peter, E., McNally, G., & Kuaimba, O. (2015). A bridge too far? The influence of socio-cultural values on the adaptation responses of smallholders to a devastating pest outbreak in cocoa. *Global Environmental Change, 35*, 1-11. doi:https://doi.org/10.1016/j.gloenvcha.2015.07.012

De'ath, G., & Fabricius, K. E. (2000). CLASSIFICATION AND REGRESSION TREES: A POWERFUL YET SIMPLE TECHNIQUE FOR ECOLOGICAL DATA ANALYSIS. *Ecology, 81*(11), 3178-3192. doi:doi:10.1890/0012-9658(2000)081[3178:CARTAP]2.0.CO;2

Dey, M., Briones, R., Garcia, Y., Nissapa, A., Rodriguez, U. P., Talukder, R., Senaratne, A., Omar, I. H., Koeshendrajana, S., Khiem, N. T., Yew, T. S., Weimin, M., Jayakody, D. S., Kumar, P., Bhatta, R., Haque, M. S., Rab, M. A., Chen, O. L., Luping, L., & Paraguas, F. J. (2008). *Strategies and options for increasing and sustaining fisheries and aquaculture production to benefit poorer households in Asia [PDF in letter standard]*. https://digitalarchive.worldfishcenter.org/handle/20.500.12348/1568.

Dey, M. M., Bimbao, G. B., Yong, L., Regaspi, P., Kohinoor, A. H. M., Pongthana, N., & Paraguas, F. J. (2000). Current status of production and consumption of tilapia in selected Asian countries. *Aquaculture Economics & Management, 4*(1-2), 13-31. doi:10.1080/13657300009380258

Diedrich, A., Benham, C., Pandihau, L., & Sheaves, M. (2018). Social capital plays a central role in transitions to sportfishing tourism in small-scale fishing communities in Papua New Guinea. *AMBIO*. doi:10.1007/s13280-018-1081-4

Diedrich, A., Blythe, J., Petersen, E., Euriga, E., Fatchiya, A., Shimada, T., & Jones, C. (2019). Socio-Economic Drivers of Adoption of Small-Scale Aquaculture in Indonesia. *Sustainability, 11*(6), 1543. Retrieved from http://www.mdpi.com/2071-1050/11/6/1543

Donkor, E., Onakuse, S., Bogue, J., & De Los Rios-Carmenado, I. (2019). Fertiliser adoption and sustainable rural livelihood improvement in Nigeria. *Land Use Policy, 88*, 104193. doi:https://doi.org/10.1016/j.landusepol.2019.104193

Dornan, M., & Newton Cain, T. (2014). Regional Service Delivery among Pacific Island Countries: An Assessment. *Asia & the Pacific Policy Studies, 1*(3), 541-560. doi:10.1002/app5.45

Duc, N. M. (2009). Economic contribution of fish culture to farm income in Southeast Vietnam. *Aquaculture International, 17*(1), 15-29. doi:10.1007/s10499-008-9176-8

E-Jahan, K. M., Ahmed, M., & Belton, B. (2010). The impacts of aquaculture development on food security: lessons from Bangladesh. *Aquaculture Research, 41*(4), 481-495. doi:10.1111/j.1365-2109.2009.02337.x

Ecker, O. (2018). Agricultural transformation and food and nutrition security in Ghana: Does farm production diversity (still) matter for household dietary diversity? *Food Policy, 79*, 271-282. doi:https://doi.org/10.1016/j.foodpol.2018.08.002

Edwards, P. (2000). *Aquaculture, poverty impacts and livelihoods*: Overseas Development Institute.

Edwards, P. (2010). *Review of small-scale aquaculture: definitions, characterization, numbers.* Paper presented at the FAO Expert Workshop on Enhancing the Contribution of the Small-Scale Aquaculture Sector to Food Security, Hanoi, Vietnam.

Edwards, P. (2013). *Review of small-scale aquaculture: definitions, characterization, numbers*. Retrieved from http://www.fao.org/3/a-i3118e.pdf:

El-Sayed, A. F. M. (2006). *Tilapia Culture*. Wallingford, UNITED KINGDOM: CABI.

Eldredge, L. G., & Humphries, J. D. (1994). *Perspectives in aquatic exotic species management in the Pacific Islands*. Retrieved from http://www.botany.hawaii.edu/basch/uhnpscesu/pdfs/sam/Eldredge1994AS.pdf

Eltholth, M., Fornace, K., Grace, D., Rushton, J., & Häsler, B. (2015). Characterisation of production, marketing and consumption patterns of farmed tilapia in the Nile Delta of Egypt. *Food Policy, 51*, 131-143. doi:https://doi.org/10.1016/j.foodpol.2015.01.002

Eme, P. E., Burlingame, B., Douwes, J., Kim, N., & Foliaki, S. (2019). Quantitative estimates of dietary intake in households of South Tarawa, Kiribati. *Asia Pacific journal of clinical nutrition, 28*(1), 131-138. Retrieved from https://search.informit.com.au/documentSummary;dn=264836125309383;res=IELHEA

Eriksson, H., Sulu, R., Blythe, J. L., van der Ploeg, J., & Andrew, N. (2020). Intangible links between household livelihoods and food security in Solomon Islands: implications for rural development. *Ecology and Society, 25*(4). doi:10.5751/ES-11709-250418

Etikan, I., Musa, S. A., & Alkassim, R. S. (2016). Comparison of convenience sampling and purposive sampling. *American journal of theoretical and applied statistics, 5*(1), 1-4.

Faiau, J. K. (2013). *Exploring community-based development: A case study of the Estate and rural community development in North Malaita, Solomon Islands.* (Master of International Development Masters). Massey University, Palmerston North, New Zealand.

FAO. (2016). *AQUASTAT Country Profile - Solomon Islands*. Retrieved from Rome, Italy:

FAO. (2020) The State of World Fisheries and Aquaculture 2020. Sustainability in action. In, *The State of World Fisheries and Aquaculture (SOFIA)* (pp. 244). Rome, Italy: Food and Agriculture Organisation.

FAO, IFAD, UNICEF, WFP, & WHO. (2020). *The State of Food Security and Nutrition in the World. Transforming Food systems for affordable healthy diets*. Retrieved from https://doi.org/10.4060/ca9692en:

Farmery, A. K., Scott, J. M., Brewer, T. D., Eriksson, H., Steenbergen, D. J., Albert, J., Raubani, J., Tutuo, J., Sharp, M. K., & Andrew, N. L. (2020). Aquatic Foods and Nutrition in the Pacific. *Nutrients, 12*(12), 3705. Retrieved from https://www.mdpi.com/2072-6643/12/12/3705

Farquhar, S. D., Khanal, N., Shrestha, M., Farthing, M., & Bhujel, R. C. (2018). Socio-economic impacts of the Women in Aquaculture (WiA) project in Nepal. *Kasetsart Journal of Social Sciences*. doi:https://doi.org/10.1016/j.kjss.2017.12.014

Fernandez, P. R. (2013). Governance institutions and the adaptive capacity of small-scale aquaculture to climate change in the Philippines. *Enhancing the contribution of small-scale aquaculture to food security, poverty alleviation and socio-economic development*, 153.

Flores, R. M. V., & Pedroza Filho, M. X. (2019). Measuring the impact of fish farming on regional development of poor cities: A case study on Ceará State, Brazil. *Journal of Applied Aquaculture, 31*(4), 356-366. doi:10.1080/10454438.2019.1600095

Fly, J. K. (2016). Shrimp Aquaculture, Social Capital, and Food Security in Rural Vietnam. *Culture, Agriculture, Food and Environment, 38*(2), 113-122. doi:10.1111/cuag.12076

Foale, S., Cohen, P., Januchowski-Hartley, S., Wenger, A., & Macintyre, M. (2011). Tenure and taboos: origins and implications for fisheries in the Pacific. *Fish and Fisheries, 12*(4), 357-369. doi:10.1111/j.1467-2979.2010.00395.x

Funge-Smith, S., & Bennett, A. (2019). A fresh look at inland fisheries and their role in food security and livelihoods. *Fish and Fisheries, 20*(6), 1176-1195. doi:10.1111/faf.12403

Genschick, S., Marinda, P., Tembo, G., Kaminski, A. M., & Thilsted, S. H. (2018). Fish consumption in urban Lusaka: The need for aquaculture to improve targeting of the poor. *Aquaculture, 492*, 280-289. doi:https://doi.org/10.1016/j.aquaculture.2018.03.052

Gereva, S. (2014). *An evaluation of the culture performance of two Macrobrachium species in Vanuatu: the exotic M. rosenbergii and the indigenous M. lar.* (Masters in Applied Science). Queensland University of Technology, Brisbane, Australia.

Gillett, R. (2016). *Fisheries in the Economies of Pacific Island Countries and Territories* (2 ed.). Noumea, New Caledonia: Pacific Community.

Gillett, R., Preston, G., Nash, W., Govan, H., Adams, T., & Lam, M. (2008). Livelihood diversification as a marine resource management tool in the Pacific Islands: Lessons learned. *SPC Fisheries Newsletter, 125*, 32-39.

Glendinning, A., Mahapatra, A., & Mitchell, C. P. (2001). Modes of Communication and Effectiveness of Agroforestry Extension in Eastern India. *Human Ecology, 29*(3), 283-305. doi:10.1023/a:1010954631611

Gordon, A., Finegold, C., Crissman, C., & Pulis, A. (2013). Fish production, consumption, and trade in Sub-Saharan Africa: A review analysis. *WorldFish report prepared for World Bank Fish to, 2030*.

Goris, J., Zomerdijk, N., & Temple, V. (2016). Nutritional status and dietary diversity of Kamea in Gulf Province, Papua New Guinea. *Asia Pacific journal of clinical nutrition, Online first*. doi:10.6133/apjcn.052016.09

Govan, H. (2011). *How can we support communities to build on what they have for a better life? Supplementary livelihoods in the Pacific*.

Grieve, H., Busch-Hallen, J., & Mellor, K. (2013). Undernutrition in Pacific Island Countries: An issue requiring further attention. Retrieved from http://www.wchknowledgehub.com.au/sites/default/files/PB_Grieve_May2013.pdf

Grivetti, L. E. (2019). The rationale, promise, and realities of aquaculture: a cultural-nutritional perspective. In J. L. Smith & S. Peterson (Eds.), *Aquaculture Development In Less Developed Countries* (pp. 11-20). New York and Oxon, USA: Routledge.

Guo, C., & Acar, M. (2005). Understanding Collaboration Among Nonprofit Organizations: Combining Resource Dependency, Institutional, and Network Perspectives. *Nonprofit and Voluntary Sector Quarterly, 34*(3), 340-361. doi:10.1177/0899764005275411

Gupta, V. M., & Acosta, O. B. (2004). A review of global tilapia farming practices. In *Aquac. Asia* (Vol. 9). https://www.semanticscholar.org/paper/A-review-of-global-tilapia-farming-practices-Gupta-Acosta/684559cd29e72642e2771b96a40f8dc0983f378e.

Haddad, L., Cameron, L., & Barnett, I. (2014). The double burden of malnutrition in SE Asia and the Pacific: priorities, policies and politics. *Health Policy and Planning, 30*(9), 1193-1206. doi:10.1093/heapol/czu110

Haider, L. J., Boonstra, W. J., Peterson, G. D., & Schlüter, M. (2018). Traps and Sustainable Development in Rural Areas: A Review. *World Development, 101*, 311-321. doi:https://doi.org/10.1016/j.worlddev.2017.05.038

Hall, S. J., Hilborn, R., Andrew, N. L., & Allison, E. H. (2013). Innovations in capture fisheries are an imperative for nutrition security in the developing world. *Proceedings of the National Academy of Sciences, 110*(21), 8393-8398. doi:10.1073/pnas.1208067110

Halwart, M., Funge-Smith, S., & Moehl, J. (2003). The role of aquaculture in rural development. *Review of the State of World Aquaculture, FAO, Rome*, 47-58.

Hambrey, & Nautilus. (2012). *Opportunities for the development of the Pacific islands' mariculture sector*. Retrieved from https://pacificdata.org/data/dataset/oai-www-spc-int-35aefa56-0d5b-462d-a4eb-18c2874cb727

Harohau, D., Sulu, R. J., Phillips, M. J., Sukulu, M., Pickering, T., & Schwarz, A. M. (2016). Improving household tilapia (Oreochromis mossambicus) aquaculture through participatory action research. *Aquaculture, 465*, 272-286. doi:http://dx.doi.org/10.1016/j.aquaculture.2016.09.024

Hasimuna, O. J., Maulu, S., Monde, C., & Mweemba, M. (2019). Cage aquaculture production in Zambia: Assessment of opportunities and challenges on Lake Kariba, Siavonga district. *The Egyptian Journal of Aquatic Research, 45*(3), 281-285. doi:https://doi.org/10.1016/j.ejar.2019.06.007

Hays, N. P., & Roberts, S. B. (2003). AGING – NUTRITIONAL ASPECTS. In B. Caballero (Ed.), *Encyclopedia of Food Sciences and Nutrition (Second Edition)* (pp. 81-87). Oxford: Academic Press.

Hicks, C. C., Cohen, P. J., Graham, N. A. J., Nash, K. L., Allison, E. H., D'Lima, C., Mills, D. J., Roscher, M., Thilsted, S. H., Thorne-Lyman, A. L., & MacNeil, M. A. (2019). Harnessing global fisheries to tackle micronutrient deficiencies. *Nature, 574*(7776), 95-98. doi:10.1038/s41586-019-1592-6

Hishamunda, N., Ridler, N., & Martone, E. (2014) Policy and Governance in Aquaculture: lessons learned and way forward. In. *FAO Fisheries and Aquaculture Technical Paper No.577* (pp. 59). Rome: FAO.
Hoa, N. P., Chuc, N. T. K., & Thorson, A. (2009). Knowledge, attitudes, and practices about tuberculosis and choice of communication channels in a rural community in Vietnam. *Health Policy, 90*(1), 8-12. doi:https://doi.org/10.1016/j.healthpol.2008.08.006
Hodgson, G. (2006). What Are Institutions? *Journal of Economic Issues, XL*, 1-25. doi:10.1080/00213624.2006.11506879
Hodgson, G. (2007). What Are Institutions. *Voprosy Economiki, 8*, 28-48.
Horsey, B., Swanepoel, L., Underhill, S., Aliakbari, J., & Burkhart, S. (2019). Dietary Diversity of an Adult Solomon Islands Population. *Nutrients, 11*(7), 1622. doi:10.3390/nu11071622
Hoskin, M. L., Hutchison, M. J., Barnes, A. C., Ovenden, J. R., & Pope, L. C. (2015). Parental contribution to progeny during experimental spawning of jungle perch, Kuhlia rupestris. *Marine and Freshwater Research, 66*(4), 375-380. doi:https://doi.org/10.1071/MF13313
Hudson, S., Krogman, N., & Beckie, M. (2016). Social practices of knowledge mobilization for sustainable food production: nutrition gardening and fish farming in the kolli hills of India. *Food Security, 8*(3), 523-533. doi:10.1007/s12571-016-0580-z
Hughes, R. G., & Lawrence, M. (2005). Globalisation, food and health in Pacific Island countries. *Asia Pacific journal of clinical nutrition, 14*(4), 298-305.
Hughes, R. G., & Marks, G. C. (2010). Against the Tide of Change: Diet and Health in the Pacific Islands. *Journal of the American Dietetic Association, 110*(5, Supplement), S40-S43. doi:https://doi.org/10.1016/j.jada.2010.03.006
Irwin, S., Flaherty, M. S., & Carolsfeld, J. (2020). The contribution of small-scale, privately owned tropical aquaculture to food security and dietary diversity in Bolivia. *Food Security*. doi:10.1007/s12571-020-01104-0
Jones, A. D., Shrinivas, A., & Bezner-Kerr, R. (2014a). Farm production diversity is associated with greater household dietary diversity in Malawi: Findings from nationally representative data. *Food Policy, 46*, 1-12. doi:https://doi.org/10.1016/j.foodpol.2014.02.001
Jones, C., Schwarz, A.-M., Sulu, R., & Tikai, P. (2014b). *Foods and diets of communities involved in inland aquaculture in Malaita Province, Solomon Islands* (30). Retrieved from http://aquaticcommons.org/id/eprint/15603
Jupiter, S., McCarter, J., Albert, S., Hughes, A., & Grinham, A. (2019). Chapter 39 - Solomon Islands: Coastal and Marine Ecosystems. In C. Sheppard (Ed.), *World Seas: an Environmental Evaluation (Second Edition)* (pp. 855-874): Academic Press.
Kaminski, A., Gellner, M., Giese, D., Jabborov, S., Lootz, M., Lundeba, M., Nyika, B., Patt, N., Sadeghi, A., & Siachinga, M. (2019). *Opportunities and challenges for small-scale aquaculture in Zambia*. https://hdl.handle.net/20.500.12348/3629.
Kapanda, K., Ng'ong'ola, D., Matiya, G., Tchale, H., Jamu, D., & Kaunda, E. (2003). Factors affecting adoption of fish farming in Malawi: A case of Mchinji Rural Development Programme. *Aqua-Fish Technical Report*(2), 34-38.
Karim, M., & Little, D. C. (2018). The impacts of integrated homestead pond-dike systems in relation to production, consumption and seasonality in central north Bangladesh. *Aquaculture Research, 49*(1), 313-334. doi:doi:10.1111/are.13462
Karim, M., Ullah, H., Castine, S., Islam, M. M., Keus, H. J., Kunda, M., Thilsted, S. H., & Phillips, M. (2017). Carp–mola productivity and fish consumption in small-scale homestead aquaculture in Bangladesh. *Aquaculture International, 25*(2), 867-879. doi:10.1007/s10499-016-0078-x
Kawarazuka, N., & Béné, C. (2011). The potential role of small fish species in improving micronutrient deficiencies in developing countries: building evidence. *Public Health*

Nutrition, 14(11), 1927-1938. doi:http://dx.doi.org/10.1017/S1368980011000814
Kennedy, G., Ballard, T., & Dop, M. C. (2011). *Guidelines for measuring household and individual dietary diversity*. Retrieved from Rome, Italy: http://www.fao.org/publications/card/en/c/5aacbe39-068f-513b-b17d-1d92959654ea/
Keppel, G., Morrison, C., Hardcastle, J., Rounds, I., Hurahura, F., & Shed, P. (2012). Conservation in Pacific Island countries: case studies of successful programs. *PARKS, 18*, 111-123.
Khondker, M.-e.-J., Ali, H., Upraity, V., Gurung, S., Dhar, G. C., & Belton, B. (2018). Making sense of the market: Assessing the participatory market chain approach to aquaculture value chain development in Nepal and Bangladesh. *Aquaculture, 493*, 395-405. doi:https://doi.org/10.1016/j.aquaculture.2017.06.003
Kiptot, E., Franzel, S., Hebinck, P., & Richards, P. (2006). Sharing seed and knowledge: farmer to farmer dissemination of agroforestry technologies in western Kenya. *Agroforestry Systems, 68*(3), 167-179. doi:10.1007/s10457-006-9007-8
Kobayashi, M., Msangi, S., Batka, M., Vannuccini, S., Dey, M. M., & Anderson, J. L. (2015). Fish to 2030: The Role and Opportunity for Aquaculture. *Aquaculture Economics & Management, 19*(3), 282-300. doi:10.1080/13657305.2015.994240
Koppmair, S., Kassie, M., & Qaim, M. (2017). Farm production, market access and dietary diversity in Malawi. *Public Health Nutrition, 20*(2), 325-335. doi:10.1017/S1368980016002135
Krause, G., Billing, S.-L., Dennis, J., Grant, J., Fanning, L., Filgueira, R., Miller, M., Pérez Agúndez, J. A., Stybel, N., Stead, S. M., & Wawrzynski, W. (2020). Visualizing the social in aquaculture: How social dimension components illustrate the effects of aquaculture across geographic scales. *Marine Policy, 118*, 103985. doi:https://doi.org/10.1016/j.marpol.2020.103985
Krause, G., Brugere, C., Diedrich, A., Ebeling, M. W., Ferse, S. C. A., Mikkelsen, E., Pérez Agúndez, J. A., Stead, S. M., Stybel, N., & Troell, M. (2015). A revolution without people? Closing the people–policy gap in aquaculture development. *Aquaculture, 447*, 44-55. doi:http://dx.doi.org/10.1016/j.aquaculture.2015.02.009
Kruijssen, F., McDougall, C. L., & van Asseldonk, I. J. M. (2018). Gender and aquaculture value chains: A review of key issues and implications for research. *Aquaculture, 493*, 328-337. doi:https://doi.org/10.1016/j.aquaculture.2017.12.038
Kuehne, G., Llewellyn, R., Pannell, D. J., Wilkinson, R., Dolling, P., Ouzman, J., & Ewing, M. (2017). Predicting farmer uptake of new agricultural practices: A tool for research, extension and policy. *Agricultural Systems, 156*, 115-125. doi:https://doi.org/10.1016/j.agsy.2017.06.007
Kumaran, M., Ghoshal, T. K., De, D., Biswas, G., Raja, R. A., Anand, P. S., Panigrahi, A., & Vijayan, K. K. (2020). Aquaculture-based production systems for the livelihood security of coastal farm families in the risk-prone agro-ecosystem of India: an appraisal. *Aquaculture International*. doi:10.1007/s10499-019-00495-y
Kumaran, M., Vimala, D. D., Chandrasekaran, V. S., Alagappan, M., & Raja, S. (2012). Extension Approach for an Effective Fisheries and Aquaculture Extension Service in India. *The Journal of Agricultural Education and Extension, 18*(3), 247-267. doi:10.1080/1389224X.2012.670442
Lado, C. (1998). The transfer of agricultural technology and the development of small-scale farming in rural Africa: Case studies from Ghana, Sudan, Uganda, Zambia and South Africa. *GeoJournal, 45*(3), 165-176. doi:10.1023/a:1006931320926
Lako, J., Natasha, J., & South, G. R. (2018) Consumer preferences for Nile tilapia (Oreochromis niloticus) value-added products in Samoa. In. https://coastfish.spc.int/publications/bulletins/hina-les-femmes-et-la-peche/488-women-in-fisheries-information-bulletin-28.
Lal, S. N., & Foscarini, R. (1990). Introduction of tilapia species and constraints to tilapia

farming in Fiji.
Lam, V. W. Y., Allison, E. H., Bell, J. D., Blythe, J., Cheung, W. W. L., Frölicher, T. L., Gasalla, M. A., & Sumaila, U. R. (2020). Climate change, tropical fisheries and prospects for sustainable development. *Nature Reviews Earth & Environment*. doi:10.1038/s43017-020-0071-9
Landi, M., Swakin, E., Minijihau, C., Welch, H., Tefuarani, N., & Duke, T. (2016). Severe malnutrition in children in Papua New Guinea: effect of a multi-faceted intervention to improve quality of care and nutritional outcomes. *Paediatrics and International Child Health*, 1-8. doi:10.1080/20469047.2015.1106079
Limuwa, M., Singini, W., & Storebakken, T. (2018). Is Fish Farming an Illusion for Lake Malawi Riparian Communities under Environmental Changes? *Sustainability, 10*(5), 1453. Retrieved from http://www.mdpi.com/2071-1050/10/5/1453
Lo, A., Chernoff, H., Zheng, T., & Lo, S.-H. (2015). Why significant variables aren't automatically good predictors. *Proceedings of the National Academy of Sciences, 112*(45), 13892-13897. doi:10.1073/pnas.1518285112
Loh, W. Y. (2011). Classification and regression trees. *Wiley Interdisciplinary Reviews: Data Mining and Knowledge Discovery, 1*(1), 14-23. doi:doi:10.1002/widm.8
Lund, E. K. (2013). Health benefits of seafood; Is it just the fatty acids? *Food Chemistry, 140*(3), 413-420. doi:https://doi.org/10.1016/j.foodchem.2013.01.034
Lyons, G., Dean, G., Tongaiaba, R., Halavatau, S., Nakabuta, K., Lonalona, M., & Susumu, G. (2020). Macro- and Micronutrients from Traditional Food Plants Could Improve Nutrition and Reduce Non-Communicable Diseases of Islanders on Atolls in the South Pacific. *Plants, 9*(8), 942. Retrieved from https://www.mdpi.com/2223-7747/9/8/942
Lyons, G., Taylor, M., Goebel, R., Stanley, K.-J., Tikai, P., Kafa, R., Taufa, L., Orero, N., Ernst, G., Garcia, A., Paul, T., & Redfern, T. (2014). *Feasibility study on increasing the consumption of nutritionally rich leafy vegetables by indigenous communities in Samoa, Solomon Islands and Northern Australia*. Retrieved from Canberra ACT 2601, Australia:
Macaranas, J. M., Mather, P. B., Lal, S. N., Vereivalu, T., Lagibalavu, M., & Capra, M. F. (1997). Genotype and environment: A comparative evaluation of four tilapia stocks in Fiji. *Aquaculture, 150*(1), 11-24. doi:https://doi.org/10.1016/S0044-8486(96)01464-0
Makate, C., Makate, M., & Mango, N. (2019). Wealth-related inequalities in adoption of drought-tolerant maize and conservation agriculture in Zimbabwe. *Food Security*. doi:10.1007/s12571-019-00946-7
Mandima, J. J. (1995). Socioeconomic factors that influence the adoption of small-scale rural fish farming at household level in Zimbabwe. *Naga, the ICLARM Quarterly, 18*(2), 25-29.
Margaret, G., & Gakuu, C. (2018). Factors Influencing Sustainability of Small Scale Fish Farming Projects in Kenya: The Case of South Imenti Sub-County, Meru County. 17-32.
Mather, P., & Nandlal, S. (2013). Developing sustainable fish farming in the Western Pacific: a viewpoint on potential reasons for why many attempts failed. *Editorial Board*, 279.
Mathews, A. E., Al-Rajhi, A., & Kane, A. S. (2018). Validation of a photographic seafood portion guide to assess fish and shrimp intakes. *Public Health Nutrition, 21*(5), 896-901. doi:10.1017/S1368980017000945
McKinna, E. M., Nandlal, S., Mather, P. B., & Hurwood, D. A. (2010). An investigation of the possible causes for the loss of productivity in genetically improved farmed tilapia strain in Fiji: inbreeding versus wild stock introgression. *Aquaculture Research, 41*(11), e730-e742. doi:https://doi.org/10.1111/j.1365-2109.2010.02539.x
Mekonnen, D. A., Talsma, E. F., Trijsburg, L., Linderhof, V., Achterbosch, T., Nijhuis, A., Ruben, R., & Brouwer, I. D. (2020). Can household dietary diversity inform about nutrient adequacy? Lessons from a food systems analysis in Ethiopia. *Food Security*.

doi:10.1007/s12571-020-01056-5
Meyer, G. (2004). Diffusion Methodology: Time to Innovate? *Journal of Health Communication, 9*(sup1), 59-69. doi:10.1080/10810730490271539
Mignouna, D. B., Manyong, V. M., Rusike, J., Mutabazi, K. D., & Senkondo, E. M. (2011). Determinants of Adopting Imazapyr-Resistant Maize Technologies and its Impact on Household Income in Western Kenya. *http://agbioforum.org/v14n3/v14n3a07-mignouna.htm*.
Ministry of Development Planning and Aid Co-ordination. (2016). *Solomon Islands Government National Development Strategy 2016 to 2035*. Retrieved from https://www.pacificclimatechange.net/document/solomon-islands-national-development-strategy-2016-2035
Ministry of Economy Republic of Fiji. (2017). *5-year & 20-year national development plan: transforming Fiji*. Retrieved from https://www.preventionweb.net/english/professional/policies/v.php?id=59159
Solomon Islands Aquaculture development plan 2009-2014, (2009).
Ministry of Fisheries and Marine Resources. (2010). *Solomon Islands Tilapia Action Plan 2010-2015*. Retrieved from https://www.google.com/search?client=firefox-b-d&q=solomon+islands+national+tilapia+action+plan:
Ministry of Fisheries and Marine Resources. (2018). *Solomon Islands National Aquaculture Management and Development Plan 2018-2023*. Retrieved from Noumea, New Caledonia:
Minter, T., Orirana, G., Boso, D., & Van der Pleog, J. (2018). *From happy hour to hungry hour: Logging, fisheries and food security in Malaita, Solomon Islands*. Retrieved from https://www.worldfishcenter.org/content/happy-hour-hungry-hour-logging-fisheries-and-food-security-malaita-solomon-islands:
Mittal, S., & Mehar, M. (2016). Socio-economic Factors Affecting Adoption of Modern Information and Communication Technology by Farmers in India: Analysis Using Multivariate Probit Model. *The Journal of Agricultural Education and Extension, 22*(2), 199-212. doi:10.1080/1389224X.2014.997255
Mohan Dey, M., Rab, M. A., Paraguas, F. J., Piumsombun, S., Bhatta, R., Ferdous Alam, M., & Ahmed, M. (2005). FISH CONSUMPTION AND FOOD SECURITY: A DISAGGREGATED ANALYSIS BY TYPES OF FISH AND CLASSES OF CONSUMERS IN SELECTED ASIAN COUNTRIES. *Aquaculture Economics & Management, 9*(1-2), 89-111. doi:10.1080/13657300590961537
Mohanty, B. P., Mahanty, A., Ganguly, S., Mitra, T., Karunakaran, D., & Anandan, R. (2019). Nutritional composition of food fishes and their importance in providing food and nutritional security. *Food Chemistry, 293*, 561-570. doi:https://doi.org/10.1016/j.foodchem.2017.11.039
Molea, T., & Vuki, V. (2008). Subsistence fishing and fish consumption patterns of the saltwater people of the Lau Lagoon, Malaita, Solomon Islands: A case study of Funa'afou and Niuleni islanders. *SPC Women in Fisheries Bulletin, 18*, 30-35.
Moore, C. (2015). Honiara: Arrival City and Pacific Hybrid Living Space. *The Journal of Pacific History, 50*(4), 419-436. doi:10.1080/00223344.2015.1110869
Morgan, M., Terry, G., Rajaratnam, S., & Pant, J. (2016). Socio-cultural dynamics shaping the potential of aquaculture to deliver development outcomes. *Reviews in Aquaculture*, 1-9. doi:10.1111/raq.12137
Morse, S., & McNamara, N. (2013). *Sustainable Livelihood Approach : A Critique of Theory and Practice*. Dordrecht, NETHERLANDS: Springer.
Mueller, K. B., Taylor, W. W., Frank, K. A., Robertson, J. M., & Grinold, D. L. (2008). Social Networks and Fisheries: The Relationship between a Charter Fishing Network, Social Capital, and Catch Dynamics. *North American Journal of Fisheries Management, 28*(2), 447-462. doi:10.1577/M07-016.1

Mulokozi, D. P., Mmanda, F. P., Onyango, P., Lundh, T., Tamatamah, R., & Berg, H. (2020). Rural aquaculture: Assessment of its contribution to household income and farmers' perception in selected districts, Tanzania. *Aquaculture Economics & Management*, 1-19. doi:10.1080/13657305.2020.1725687

Munasinghe, M. N., Stephen, C., Abeynayake, P., & Abeygunawardena, I. S. (2010). Shrimp Farming Practices in the Puttallam District of Sri Lanka: Implications for Disease Control, Industry Sustainability, and Rural Development. *Veterinary Medicine International, 2010*, 7. doi:10.4061/2010/679130

Murshed-E-Jahan, K., & Pemsl, D. E. (2011). The impact of integrated aquaculture–agriculture on small-scale farm sustainability and farmers' livelihoods: Experience from Bangladesh. *Agricultural Systems, 104*(5), 392-402. doi:https://doi.org/10.1016/j.agsy.2011.01.003

Mwanja, W. W., Akol, A., Abubaker, L., Mwanja, M., Msuku, S. B., & Bugenyi, F. (2007). Status and impact of rural aquaculture practice on Lake Victoria basin wetlands. *African Journal of Ecology, 45*(2), 165-174. doi:10.1111/j.1365-2028.2006.00691.x

Naegel, L. C. A. (1995). Research with a farming systems perspective needed for the development of small-scale aquaculture in non-industrialized countries. *Aquaculture International, 3*(4), 277-291. doi:10.1007/bf00121619

Nakano, Y., Tsusaka, T. W., Aida, T., & Pede, V. O. (2018). Is farmer-to-farmer extension effective? The impact of training on technology adoption and rice farming productivity in Tanzania. *World Development, 105*, 336-351. doi:https://doi.org/10.1016/j.worlddev.2017.12.013

Namudu, M. T., & Pickering, T. D. (2006). Rapid Survey Technique Using Socio-Economic Indicators to Assess the Suitability of Pacific Island Rural Communities for Kappaphycus Seaweed Farming Development. *Journal of Applied Phycology, 18*(3), 241-249. doi:10.1007/s10811-006-9023-0

Nandlal, S. (2012). *Freshwater aquaculture production in the South Pacific region as a means of increasing regional food security and sustainability* (80). Retrieved from http://aciar.gov.au/publication/TR080

Nandlal, S., & Foscarini, R. (1990). Introduction if tilapia species and constraints to tilapia farming in Fiji. Retrieved from http://www.fao.org/docrep/field/003/ac295e/ac295e00.htm#ref1

Nash, K. L., Blythe, J. L., Cvitanovic, C., Fulton, E. A., Halpern, B. S., Milner-Gulland, E. J., Addison, P. F. E., Pecl, G. T., Watson, R. A., & Blanchard, J. L. (2020). To Achieve a Sustainable Blue Future, Progress Assessments Must Include Interdependencies between the Sustainable Development Goals. *One Earth, 2*(2), 161-173. doi:https://doi.org/10.1016/j.oneear.2020.01.008

Ndah, H. T., Knierim, A., & Ndambi, O. A. (2011). Fish Pond Aquaculture in Cameroon: A Field Survey of Determinants for Farmers' Adoption Behaviour. *The Journal of Agricultural Education and Extension, 17*(4), 309-323. doi:10.1080/1389224X.2011.576578

Ngoc, P. T. A., Meuwissen, M. P. M., Le, T. C., Bosma, R. H., Verreth, J., & Lansink, A. O. (2016). Adoption of recirculating aquaculture systems in large pangasius farms: A choice experiment. *Aquaculture, 460*, 90-97. doi:https://doi.org/10.1016/j.aquaculture.2016.03.055

Nico, L., & Walsh, S. (2011). *Non-indigenous freshwater fishes on tropical Pacific islands: a review of eradication efforts*.

Nyambo, B., & Ligate, E. (2013). Smallholder Information Sources and Communication Pathways for Cashew Production and Marketing in Tanzania: An Ex-post Study in Tandahimba and Lindi Rural Districts, Southern Tanzania. *The Journal of Agricultural Education and Extension, 19*(1), 73-92. doi:10.1080/1389224X.2012.746004

Nzevu, J., Dorothy, A., Amos, K., & Amos, M. (2018). The contribution of fish farming to

household wellbeing of Fish Farmers in Kitui Central Sub-County, Kitui County. *Journal of Agriculture and Veterinary Sciences, 11*, 69-76. doi:10.9790/2380-1101016976

O'Garra, T. (2007). *Supplementary livelihood for pacific island communities: A review of experiences*. Retrieved from http://www.fspi.org.fj/index.php/sustainable-livelihoods-resources/reports:

O'Meara, L., Williams, S. L., Hickes, D., & Brown, P. (2019). Predictors of Dietary Diversity of Indigenous Food-Producing Households in Rural Fiji. *Nutrients, 11*(7), 1629. Retrieved from https://www.mdpi.com/2072-6643/11/7/1629

Obiero, K., Meulenbroek, P., Drexler, S., Dagne, A., Akoll, P., Odong, R., Kaunda-Arara, B., & Waidbacher, H. (2019). The Contribution of Fish to Food and Nutrition Security in Eastern Africa: Emerging Trends and Future Outlooks. *Sustainability, 11*(6), 1636. Retrieved from http://www.mdpi.com/2071-1050/11/6/1636

Ofuoku, A. U., Olele, N. F., & Emah, G. N. (2008). Determinants of Adoption of Improved Fish Production Technologies among Fish Farmers in Delta State, Nigeria. *The Journal of Agricultural Education and Extension, 14*(4), 297-306. doi:10.1080/13892240802416186

Pacific Community, Women in Fisheries Network, & Fiji Ministry of Fisheries. (2018). *Gender analysis of the aquaculture sector in Fiji: Community-based tilapia farms in Viti Levu*. Retrieved from https://www.spc.int/resource-centre/gender-analysis-of-the-aquaculture-sector-in-fiji-community-based-tilapia-farms-in:

Padel, S. (2001). Conversion to Organic Farming: A Typical Example of the Diffusion of an Innovation? *Sociologia Ruralis, 41*(1), 40-61. doi:10.1111/1467-9523.00169

Palanca-Tan, R. (2018). Aquaculture, poverty and environment in the philippines. *Journal of Social, Political, and Economic Studies, 43*(3-4), 294-315. Retrieved from https://www.scopus.com/inward/record.uri?eid=2-s2.0-85054591174&partnerID=40&md5=cba9012a28a449069651c86a2130bdb0

Pandey, D., & Upadhyay, A. (2012). *Socio-Economic Profile of Fish Farmers of an Adopted Model Aquaculture Village: Kulubari, West Tripura* (Vol. Special Issue (Volume II)).

Pannell, D. J., Marshall, G. R., Barr, N., Curtis, A., Vanclay, F., & Wilkinson, R. (2006). Understanding and promoting adoption of conservation practices by rural landholders. *Australian Journal of Experimental Agriculture, 46*(11), 1407-1424. doi:https://doi.org/10.1071/EA05037

Pant, J., Barman, B. K., Murshed-E-Jahan, K., Belton, B., & Beveridge, M. (2014). Can aquaculture benefit the extreme poor? A case study of landless and socially marginalized Adivasi (ethnic) communities in Bangladesh. *Aquaculture, 418–419*, 1-10. doi:http://dx.doi.org/10.1016/j.aquaculture.2013.09.027

Peshin, R., Vasanthakumar, J., & Kalra, R. (2009). Diffusion of Innovation Theory and Integrated Pest Management. In R. Peshin & A. K. Dhawan (Eds.), *Integrated Pest Management: Dissemination and Impact: Volume 2* (pp. 1-29). Dordrecht: Springer Netherlands.

Phuong, N. T., & Oanh, D. T. H. (2010). Striped Catfish Aquaculture in Vietnam: A Decade of Unprecedented Development. In S. S. De Silva & F. B. Davy (Eds.), *Success Stories in Asian Aquaculture* (pp. 131-147). Dordrecht: Springer Netherlands.

Pickering, T. (2010). *Tilapia fish farming in the Pacific - A responsible way forward*. Noumea, New Caledonia: Secretariat of the Pacific Community.

Pickering, T. (2015). South Santo tilapia farmers gear up to increase production. Retrieved from https://coastfish.spc.int/en/publications/bulletins/fisheries-newsletter/454-spc-fisheries-newsletter-147

Pickering, T. (2016). Samoa villagers celebrate first fish harvest from tilapia floating-cage aquaculture system. *Fisheries Newsletter*.

Pinca, S., Vunisea, A., Lasi, F., Friedman, K. J., Kronen, M., Awira, R., Boblin, P., Tardy, E.,

Chapman, L. B., & Magron, F. (2009). *Solomon Islands country report : profiles and results from survey work at Nggela, Marau, Rarumana and Chubikopi (June to September 2006 and December 2006)*.

Ploeg, J. v. d., Joelle., A., Apgar, M., Gregory, B., Delvene., B., Cohen, P., Daokalia, C., James, F., Daykin, H., Iramo, E., Orirana, G., Michelle, R., Saeni, E., Faye., S., Meshach, S., Reuben, S. J., Suruma, B., Teioli, H., Tikai, P., & A.-M., S. (2016). *Learning from the lagoon: Research in development in Solomon Islands*. Retrieved from Penang, Malaysia:

Polhemus, D. A., Englund, R. A., Allen, G. R., Boseto, D., & Polhemus, J. T. (2008). Freshwater biotas of the Solomon Islands: analysis of richness, endemism and threats. *Honolulu: Bishop Museum Technical Report, 45*.

Pollnac, R. (1978). *Sociocultural aspects of implementing aquaculture systems in marine fishing communities*.

Pollnac, R., Peterson, S., & Smith, L. (2019). Elements in Evaluating Success and Failure in Aquaculture Projects. In J. L. Smith & S. Peterson (Eds.), *Aquaculture Development in Less Developed Countries* (pp. 131-143). Lond and New York: Routledge Taylor & Francis Group.

Ponia, B. (2003) Aquaculture update for Vanuatu. In*: Vol. 105*. Noumea, New Caledonia: Secretariat of the Pacific Community.

Ponia, B. (2010). *A review of aquaculture in the pacific islands 1998-2007: tracking a decade of progress through official and provisional statistics*. Retrieved from https://g.co/kgs/YCXFEa:

Pouomogne, V., Brummett, R. E., & Gatchouko, M. (2010). Impacts of Aquaculture Development Projects in Western Cameroon. *Journal of Applied Aquaculture, 22*(2), 93-108. doi:10.1080/10454431003736078

Pratchett, M. S., Munday, P. L., Graham, N., Kronen, M., Pinica, S., Friedman, K., Brewer, T., Bell, J., Wilson, S., Cinner, J., Kinch, J., Lawton, R., Williams, A., Chapman, L., Magron, F., & Webb, A. (2011). Vulnerability of coastal fisheries in the tropical Pacific to climate change. In (pp. 941 pp).

Pritchard, B., Rammohan, A., & Vicol, M. (2019). The importance of non-farm livelihoods for household food security and dietary diversity in rural Myanmar. *Journal of Rural Studies, 67*, 89-100. doi:https://doi.org/10.1016/j.jrurstud.2019.02.017

Purcell, S. W., & Pomeroy, R. S. (2015). Driving small-scale fisheries in developing countries. *Frontiers in Marine Science, 2*(44). doi:10.3389/fmars.2015.00044

Rabbitt, S., Lilley, I., Albert, S., & Tibbetts, I. R. (2019). What's the catch in who fishes? Fisherwomen's contributions to fisheries and food security in Marovo Lagoon, Solomon Islands. *Marine Policy, 108*, 103667. doi:https://doi.org/10.1016/j.marpol.2019.103667

Richardson, A. J. (2003). The importance of omega-3 fatty acids for behaviour, cognition and mood. *Scandinavian Journal of Nutrition, 47*(2), 92-98. doi:10.1080/11026480310007944

Rimmer, M. A., Sugama, K., Rakhmawati, D., Rofiq, R., & Habgood, R. H. (2013). A review and SWOT analysis of aquaculture development in Indonesia. *Reviews in Aquaculture, 5*(4), 255-279. doi:10.1111/raq.12017

Ritchie, J., Lewis, J., Nicholls, C. M., & Ormston, R. (2013). *Qualitative research practice: A guide for social science students and researchers* (K. Metzlier Ed. 2nd ed.): Sage.

Rodil, S. A., & Mias-Cea, A. A. M. (2014). *Honiara, Solomon Islands Climate Change Vulnerability Assessment*. Retrieved from https://www.pacificclimatechange.net/document/honiara-solomon-islands-climate-change-vulnerability-assessment

Roeger, J., Foale, S., & Sheaves, M. (2016). When 'fishing down the food chain' results in improved food security: Evidence from a small pelagic fishery in Solomon Islands. *Fisheries Research, 174*, 250-259. doi:http://dx.doi.org/10.1016/j.fishres.2015.10.016

Rogers, E. M. (2003). *Diffusion of innovations* (5 ed.). NY, United States: The Free Press, Simon and Schuster.
Roohani, N., Hurrell, R., Kelishadi, R., & Schulin, R. (2013). Zinc and its importance for human health: An integrative review. *Journal of research in medical sciences : the official journal of Isfahan University of Medical Sciences, 18*(2), 144-157. Retrieved from https://pubmed.ncbi.nlm.nih.gov/23914218
Roos, N., Wahab, M. A., Chamnan, C., & Thilsted, S. H. (2007). The Role of Fish in Food-Based Strategies to Combat Vitamin A and Mineral Deficiencies in Developing Countries. *The Journal of Nutrition, 137*(4), 1106-1109. doi:10.1093/jn/137.4.1106
Ross, H., Adhuri, D. S., Abdurrahim, A. Y., & Phelan, A. (2019). Opportunities in community-government cooperation to maintain marine ecosystem services in the Asia-Pacific and Oceania. *Ecosystem Services, 38*, 100969. doi:https://doi.org/10.1016/j.ecoser.2019.100969
Ruddle, K. (1993). The impacts of aquaculture development on socioeconomic environments in developing countries: towards a paradigm for assessment. In R. S. V. Pullin, H. Rosenthal, & J. L. e. Maclean (Eds.), *Environment and aquaculture in developing countries* (Vol. 941, pp. 20-41).
Ruel, M. T. (2003). Operationalizing dietary diversity: a review of measurement issues and research priorities. *J Nutr, 133*(11 Suppl 2), 3911s-3926s. doi:10.1093/jn/133.11.3911S
Russell, D. J., Thuesen, P. A., & Thomson, F. E. (2012). A review of the biology, ecology, distribution and control of Mozambique tilapia, Oreochromis mossambicus (Peters 1852) (Pisces: Cichlidae) with particular emphasis on invasive Australian populations. *Reviews in Fish Biology and Fisheries, 22*(3), 533-554. doi:http://dx.doi.org/10.1007/s11160-011-9249-z
Sagar, A., & Najam, A. (1998). The Human Development Index: A Critical Review. *Ecological Economics, 25*, 249-264. doi:10.1016/S0921-8009(97)00168-7
Salazar, C., Jaime, M., Figueroa, Y., & Fuentes, R. (2018). Innovation in small-scale aquaculture in Chile. *Aquaculture Economics & Management, 22*(2), 151-167. doi:10.1080/13657305.2017.1409293
Scholtens, J., & Bavinck, M. (2017). Oceans' contribution to food security for the poor: confronting ominous trends. *Current Conservation, 11*, 3-8.
Schwarz, A. M., Andrew, N., Govan, H., Harohau, D., & Oeta, J. (2013). *Solomon Islands Malaita Hub Scoping Report*. Retrieved from https://www.worldfishcenter.org/content/solomon-islands-malaita-hub-scoping-report:
Scoones, I. (1998) Sustainable rural livelihoods: a framework for analysis. In, *ODS working papers*. Brighton, United Kingdom: Institute of Development Studies.
Secretariat of the Pacific Community. (2008). *SPC Policy Brief #1: Fish and Food Security*. www.spc.int
Secretariat of the Pacific Community. (2013). *Status report: Pacific Islands reef and nearshore fisheries and aquaculture 2013*. Retrieved from Noumea, New Caledonia: http://www.spc.int/en/digital-library.html
Secretariat of the Pacific Community. (2015). *A new song for coastal fisheries – pathways to change: The Noumea strategy*. Noumea, New Caledonia: Secretariat of the Pacific Community
Secretariat of the Pacific Community, & CSIRO. (2011). *Food Security in the Pacific and East Timor and its vulnerability to climate change*. Retrieved from Noumea, New Caledonia:
Senff, P., Partelow, S., Indriana, L. F., Buhari, N., & Kunzmann, A. (2018). Improving pond aquaculture production on Lombok, Indonesia. *Aquaculture, 497*, 64-73. doi:https://doi.org/10.1016/j.aquaculture.2018.07.027
Sheheli, S., Fatema, K., & Haque, S. M. (2014). Existing Status and Practices of Fish Farming in Trishal Upazila of Mymensingh District. *Progressive Agriculture, 24*. doi:10.3329/pa.v24i1-2.19172

Shepon, A., Gephart, J. A., Henriksson, P. J. G., Jones, R., Murshed-e-Jahan, K., Eshel, G., & Golden, C. D. (2020). Reorientation of aquaculture production systems can reduce environmental impacts and improve nutrition security in Bangladesh. *Nature Food, 1*(10), 640-647. doi:10.1038/s43016-020-00156-x

Sievert, K., Lawrence, M., Naika, A., & Baker, P. (2019). Processed Foods and Nutrition Transition in the Pacific: Regional Trends, Patterns and Food System Drivers. *Nutrients, 11*(6), 1328. doi:10.3390/nu11061328

Sileshi, M., Kadigi, R., Mutabazi, K., & Sieber, S. (2019). Determinants for adoption of physical soil and water conservation measures by smallholder farmers in Ethiopia. *International Soil and Water Conservation Research*. doi:https://doi.org/10.1016/j.iswcr.2019.08.002

Slater, M. J., Mgaya, Y. D., Mill, A. C., Rushton, S. P., & Stead, S. M. (2013). Effect of social and economic drivers on choosing aquaculture as a coastal livelihood. *Ocean & Coastal Management, 73*, 22-30. doi:http://dx.doi.org/10.1016/j.ocecoaman.2012.12.002

Smith, L., & Peterson, S. (Eds.). (2019). *Aquaculture development in less developed countries: social, economic, and political problems*. 2 Park Square, Milton Park, Abingdon, Oxon OX14 4RN: Routledge.

Smith, L. J., & Peterson, S. (1982). An introduction to aquaculture development. *Aquaculture Development in Less Developed Countries: Social, Economic, and Political Problems*.

Smith, P. T. (2007). *Aquaculture in Papua New Guinea: status of freshwater fish farming*. Retrieved from http://aciar.gov.au/publication/mn125:

Smith, P. T. (2013). *Small-Scale aquaculture in Papua New Guinea: Examination of entry points for international aid donors.* Paper presented at the FAO expert workshop on Enhancing the contribution of the Small-scale Aquaculture Sector to Food Security, Poverty Alleviation and Socio-economic Development, Hanoi, Vietnam.

Snowdon, W., Raj, A., Reeve, E., Guerrero, R. L. T., Fesaitu, J., Cateine, K., & Guignet, C. (2013). Processed foods available in the Pacific Islands. *Globalization and Health, 9*(1), 53. doi:10.1186/1744-8603-9-53

Solesbury, W. (2003). Sustainable Livelihoods: A Case Study of the Evolution of DFID Policy. *Working Paper 217*. doi:10.3362/9781780444598.006

Solomon Islands Ministry of Fisheries and Marine Resources. (2019). *Solomon Islands National Fisheries Policy 2019–2029: A Policy for the conservation, management, development and sustainable use of the fisheries and aquatic resources of Solomon Islands*. https://www.spc.int/DigitalLibrary/FAME/Search: MFMR

Solomon Islands National Statistics Office. (2015). *Household Income and Expenditure Survey 2012/13: Volume 1- National Analytical Report*. Retrieved from http://www.statistics.gov.sb/:

Solomon Islands National Statistics Office. (2020). *Provisional Count 2019 National Population and Housing Census*. https://www.statistics.gov.sb/

Speedy, A. W. (2003). Global Production and Consumption of Animal Source Foods. *The Journal of Nutrition, 133*(11), 4048S-4053S. doi:10.1093/jn/133.11.4048S

Stevens, K., Frank, K. A., & Kramer, D. B. (2015). Do Social Networks Influence Small-Scale Fishermen's Enforcement of Sea Tenure? *PLoS ONE, 10*(3), e0121431. doi:10.1371/journal.pone.0121431

Sulu, R., Schwarz, A., Phillips, M., Perera, R., & Pickering, T. (2015a). *Final report: Developing Inland aquaculture in Solomon Islands* (FR2016-14). Retrieved from http://aciar.gov.au/publication/fr2016-14-0

Sulu, R. J., Eriksson, H., Schwarz, A.-M., Andrew, N. L., Orirana, G., Sukulu, M., Oeta, J., Harohau, D., Sibiti, S., Toritela, A., & Beare, D. (2015b). Livelihoods and Fisheries Governance in a Contemporary Pacific Island Setting. *PLoS ONE, 10*(11), e0143516. doi:10.1371/journal.pone.0143516

Sulu, R. J., Leamae, J., & Ploeg, J. v. d. (2018). *Auki fish market survey: species, volumes and*

value. Retrieved from https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/TMUJ7X
Superio, D. L., Nemiz, E. S., Oliveros, M. G. H., Palcullo, V. E. V., Yap-Zerrudo, A. M. A., & Canaman, J. B. (2018). Responsible aquaculturists:The information-seeking behavior of milkfish farmers in Iloilo, Philippines. *Information Development, 0*(0), 0266666918798675. doi:10.1177/0266666918798675
Susumu, G. (2014). *Snapshots of food and nutrition security in the Pacific Region*. Retrieved from http://www.2020resilience.ifpri.info/files/2014/06/2014-05-17_2020_PRS_9E_Susumu.pdf:
Swindale, A., & Bilinsky, P. (2006) Household Dietary Diversity Score (HDDS) for Measurement of Household Food Access: Indicator Guide In*: Vol. 2*. Washington D.C: FHI 360/Food and Nutrition Technical Assistance Project (FANTA).
Temesgen, M., Getahun, A., & Lemma, B. (2019). Livelihood Functions of Capture Fisheries in Sub-Saharan Africa: Food Security, Nutritional, and Economic Implications. *Reviews in Fisheries Science & Aquaculture, 27*(2), 215-225. doi:10.1080/23308249.2019.1565754
Tenge, A. J., Graaff, J. D., & Hella, J. P. (2004). Social and economic factors affecting the adoption of soil and water conservation in West Usambara highlands, Tanzania. *Land Degradation & Development, 15*(2), 99-114. doi:doi:10.1002/ldr.606
The WorldFish Center. (2010). Creating rural livelihoods in Solomon Islands through an environmentally friendly trade of marine ornamentals for the aquarium trade: lessons learned. . In. https://hdl.handle.net/20.500.12348/1230: The WorldFish Center.
Thilsted, S. H., Thorne-Lyman, A., Webb, P., Bogard, J. R., Subasinghe, R., Phillips, M. J., & Allison, E. H. (2016). Sustaining healthy diets: The role of capture fisheries and aquaculture for improving nutrition in the post-2015 era. *Food Policy, 61*, 126-131. doi:http://dx.doi.org/10.1016/j.foodpol.2016.02.005
Thomas, D. H. L. (1994). Socio-economic and cultural factors in aquaculture development: a case study from Nigeria. *Aquaculture, 119*(4), 329-343. doi:http://dx.doi.org/10.1016/0044-8486(94)90298-4
Toledo, J. D., Acosta, B. O., Eguia, M. R. R., Eguia, R. V., & Israel, D. C. (2008). Sustainable tilapia farming: a challenge to rural development. *Fish for the People, 6*(1), 18-25.
Townsley, G. P. (2013). *Small-scale aquaculture and its contextual relationships with the concepts of poverty, food security, rural livelihoods and development.* Paper presented at the Enhancing the contribution of small-scale aquaculture to food security, poverty alleviation and socio-economic development, Rome, Italy.
Tran, N., Chu, L., Chan, C. Y., Genschick, S., Phillips, M. J., & Kefi, A. S. (2019). Fish supply and demand for food security in Sub-Saharan Africa: An analysis of the Zambian fish sector. *Marine Policy, 99*, 343-350. doi:https://doi.org/10.1016/j.marpol.2018.11.009
Turner, R. A., Polunin, N. V. C., & Stead, S. M. (2014). Social networks and fishers; behavior: exploring the links between information flow and fishing success in the Northumberland lobster fishery. *Ecology and Society, 19*(2). doi:10.5751/ES-06456-190238
Uhunamure, S. E., Nethengwe, N. S., & Tinarwo, D. (2019). Correlating the factors influencing household decisions on adoption and utilisation of biogas technology in South Africa. *Renewable and Sustainable Energy Reviews, 107*, 264-273. doi:https://doi.org/10.1016/j.rser.2019.03.006
Umesh, N. R., Mohan, A. B. C., Ravibabu, G., Padiyar, P. A., Phillips, M. J., Mohan, C. V., & Bhat, B. V. (2010). Shrimp Farmers in India: Empowering Small-Scale Farmers through a Cluster-Based Approach. In S. S. De Silva & F. B. Davy (Eds.), *Success Stories in Asian Aquaculture* (pp. 41-66). Dordrecht: Springer Netherlands.
United Nations Children's Fund. (2017). *Situation Analysis of Children in the Pacific Island Countries*. Retrieved from https://www.unicef.org/pacificislands/reports/situation-analysis-children-pacific-island-countries
United Nations Development Program. (2020). *The Next Frontier: Human Development and*

the Anthropocene. Retrieved from http://hdr.undp.org/en/countries/profiles/SLB#:
Valmonte-Santos, R., Rosegrant, M. W., & Dey, M. M. (2016). Fisheries sector under climate change in the coral triangle countries of Pacific Islands: Current status and policy issues. *Marine Policy, 67*, 148-155. doi:http://dx.doi.org/10.1016/j.marpol.2015.12.022
Vandenberg, J., Humphries, A., Garcia-Quijanoa, C., Moore, A., Pollnac, R., & Abdullah, S. (2021). Assessing Indicators and Limitations of Food Security Objectives in Coral Reef Restoration. *Conservation and Society, 19*. doi:10.4103/cs.cs_20_33
Veatupu, L., Puloka, V., Smith, M., McKerchar, C., & Signal, L. (2019). Me'akai in Tonga: Exploring the Nature and Context of the Food Tongan Children Eat in Ha'apai Using Wearable Cameras. *International Journal of Environmental Research and Public Health, 16*(10), 1681. Retrieved from https://www.mdpi.com/1660-4601/16/10/1681
Veitayaki, J. (2000). *Realities in Rural Development: fisheries development in Fiji.* (Doctor of Philosophy). Australian National University https://www.researchgate.net/publication/327592937_Realities_in_rural_development_fisheries_development_in_Fiji.
Vereivalu, T. (1989). *Aquaculture activities in Fiji.* Paper presented at the Advances in Tropical Aquaculture, Tahiti, French Polynesia.
Villasante, S., Rivero Rodríguez, S., Molares, Y., Martínez, M., Remiro, J., García-Díez, C., Lahoz, C., Omar, I., Bechardas, M., Elago, P., Ekandjo, M., Saisai, M., & Awity, L. (2015). Are provisioning ecosystem services from rural aquaculture contributing to reduce hunger in Africa? *Ecosystem Services, 16*, 365-377. doi:http://dx.doi.org/10.1016/j.ecoser.2015.07.003
Vishnu, S., Gupta, J., & Subash, S. P. (2019). Social network structures among the livestock farmers vis a vis calcium supplement technology. *Information Processing in Agriculture, 6*(1), 170-182. doi:https://doi.org/10.1016/j.inpa.2018.07.006
Vogliano, C., Raneri, J. E., Maelaua, J., Coad, J., Wham, C., & Burlingame, B. (2021). Assessing Diet Quality of Indigenous Food Systems in Three Geographically Distinct Solomon Islands Sites (Melanesia, Pacific Islands). *Nutrients, 13*(1), 30. Retrieved from https://www.mdpi.com/2072-6643/13/1/30
Weeratunge, N., Pemsl, D., Rodriguez, P., Oai Li, C., Badjeck, M.-C., Schwarz, A.-M., Paul, C., Prange, J., & Kelling, I. (2011). *Planning the use of fish for food security in Solomon Islands*. Retrieved from http://www.worldfishcenter.org/content/planning-use-fish-food-security-solomon-islands-0
Wetengere, K. (2011). Socio-economic factors critical for intensification of fish farming technology. A case of selected villages in Morogoro and Dar es Salaam regions, Tanzania. *Aquaculture International, 19*(1), 33-49. doi:10.1007/s10499-010-9339-2
World Health Organization. (2010). Nutrition Landscape Information System (NLIS) country profile indicators: interpretation guide. In. Geneva: World Health Organization.
Zárate, R., el Jaber-Vazdekis, N., Tejera, N., Pérez, J. A., & Rodríguez, C. (2017). Significance of long chain polyunsaturated fatty acids in human health. *Clinical and Translational Medicine, 6*(1), 25. doi:10.1186/s40169-017-0153-6
Zhong, T., Si, Z., Crush, J., Xu, Z., Huang, X., Scott, S., Tang, S., & Zhang, X. (2018). The Impact of Proximity to Wet Markets and Supermarkets on Household Dietary Diversity in Nanjing City, China. *Sustainability, 10*(5), 1465. Retrieved from http://www.mdpi.com/2071-1050/10/5/1465

APPENDIX 1: Data collection forms for individual farmers

Sample interview form for tilapia farmers

Farmer's demographic.

Age	
Gender	
Marital status	Married:_____ Single: _____

1) How many people are currently in your household?

Adult male	Adult female	Male children	Female children

2) Can you read or write? [Y/N] *circle one*
3) What is the highest level of education or training you have attained?

Highest level of education	Yes (√)
Primary school	
Secondary school	
Tertiary	
Vocational training (specify what sort of training)	
Others: (specify)	

1) Do you hold any position in your village or community (E.g. head of fishermen association, church minister, head of a committee, etc.)? [Y/N] *circle one*_____
2) Do you own land here? [Y/N] *circle one*
3) If yes, is this the same land you have your tilapia farm on? [Y/N] *circle one*. If no, who's land is your tilapia pond on? _____
4) What livelihood activities do you undertake to earn food or income for your household?

Livelihood activity	Food (√)	Income (√)	Income earned weekly	Expenditure on this activity per week (e.g. Labour, seed)	Average number of days (per week or month spent on this activity)	Rank in order of importance the 3 most important. ***1-most important, 2-important, 3-least important***	
						Food	Income

5) How much of the food produced by your household is consumed in your household?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%

6) Do you have access to? (circle or specify)

Household items & facilities	Lighting	Transportation	Cooking fuel	Roof material	Wall material	Floor material	Livestock
Generator	Nothing	Private vehicle	Firewood	Sago leaves	Sago leaves	Cement	Poultry/duck

Solar panel	Solar	Public vehicle	Charcoal	Iron roofing	Timber	Timber	Cattle
Water tank	Kerosene wick	Outboard motor canoe	Kerosene	Others (specify)	Palm planks	Palm planks	Piggery
Refrigerator	Flash light	Dug-out canoe	Electric		Cement	Tiles	Goat
Electricity	Candle lit	Others (specify)	Others (specify)		Fibro	Ground/soil/earth	Others (specify)
DVD player/TV	Solar charged bulb lights				Metal	Others (specify)	
Solar battery	Others (specify)				Others (specify)		
Radio/stereo							
Mobile phone							
Flushed toilet							
Others (specify)							

Food security

7) How many meals does your household normally eat in a day?

Number	Question	Response option	code
1a.	In the past week, did you or any household member have to eat a **limited variety** of foods because of difficulties with money, bad weather, other commitments, or no place to farm (or inability to fish)?	Yes No	|___|
1b.	How often did this happen?	Rarely *(once in the past week)* Sometimes *(twice or three in the past week)* Often *(four to five times in the past week)*	|_____|
2a.	In the past week, were you or any household member not able to eat the kinds of **foods you preferred** because of difficulties with money, bad weather, other commitments, or no place to farm (or inability to fish)?	Yes No	|___|
2b.	How often did this happen?	Rarely *(once in the past week)* Sometimes *(twice or three in the past week)* Often *(four to five times in the past week)*	|_____|
3a	In the past week, did you or any household member have to eat **fewer meals per day** because there was not enough food?	Yes No	|___|
3b.	How often did this happen?	Rarely *(once in the past week)* Sometimes *(twice or three in the past week)*	|_____|

		Often *(four to five times in the past week)*	

Now, I would like to ask you some questions about how you started tilapia farming.

8) Provide answers to the questions on the left under its potential sources of information (*if there are multiple sources*)

What source(s) of information were useful to you in deciding to begin tilapia farming?	Friends	Relatives	Lead farmers	Newspaper	Pamphlets	Posters	Project officers	Radio	Others (specify)
Does this person have a tilapia pond? [Y/N]									
Location of the source *(e.g. where does the person live or where is the NGO located or is the newspaper local or national or is it a government extension agent provincial or national?)*									
How did you receive this information? ▪ *Word of mouth* ▪ *Written form (e.g. pamphlet, posters, pictures, etc)* ▪ *Radio* ▪ *TV* ▪ *Farm demonstration* ▪ *Others (specify)*									
What type of information did you find useful? ▪ *Pond construction* ▪ *Pond management (e.g. maintaining water depth, regular harvesting, etc)* ▪ *Feeding the fish* ▪ *The benefits of tilapia* ▪ *Others (specify)*									
Did this information influence your tilapia farming practice? ▪ *Yes* ▪ *No*									
Rank the 3 most important sources in influencing your adoption 1-*highest influential* 2- *influential* 3-*least influential*									

9) Did you share and exchange ideas/information about tilapia farming with other tilapia farmers? [Y/N] *Circle one*, what sort/type of information do you share?

_____

Impact on livelihood

10) How long have you been practicing tilapia farming? _____

11) What roles have your household members helped you with, with your tilapia farming?

Household members	*Specific roles played*

12) How frequently do you consume tilapia from your pond(s)?

Daily	*Weekly*	*Monthly*	*Annually*	*Haven't consumed any yet*

13) How much of the tilapia produced by your household is consumed in your household? (as opposed to being sold?)

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%

0% means all food are for sell/non-are consumed in the household, 100% means all food produced are for family consumption.

14) Do you sell tilapia from your ponds? [Y/N] *circle one*, if yes, answer the table below, if no, answer Q16

Where (e.g., at local market, at farm gate, etc.)	What? (e.g. whole fish cooked, whole fish raw, seed, etc.)	Average quantity per sale (make sure you use the same metrics across each category e.g. kilos for whole fish or # for seed, etc.)	Average price per unit (e.g., $/kilo or $/seed, etc.)	How often do you make this sale? (e.g., weekly, once a month, etc.)

15) What do you use this income for? _____

16) If you do not sell your fish, why not? Elaborate. _____

17) What are the 3 most common animal protein that you & your household consume, apart from tilapia?

18) How frequently do you & your household consume this animal sourced protein?

	Daily	Weekly	Monthly	Annually
Option 1				
Option 2				
Option 3				

19) Where did you get the animal-sourced protein from? (indicate)

	Where (e.g., at local market, neighbour, Auki market, etc.)	Cost per daily or weekly (expenditure or if no cost)
Option 1		
Option 2		
Option 3		

20) In summary, can you list and rank the benefits that you've received from participating in tilapia farming?

List of benefits	Rank *(1-most important, 2-important, 3-least important)* [rank 3 first choices]

21) What are the negative impacts of tilapia farming that you have experienced? _____

22) What innovations or new ideas have you (or members of your household) come up with for your tilapia farming?

_____

Attributes of innovation (Use smiley face card)

23) Do you feel that you have gained **respect** (in your village/community) being a tilapia farmer? Please rank your agreement.

0	1	2	3	4	5	6	7	8	9	10

0-strongly disagree 10-strongly agree

24) Do you share your fish with your neighbours/relatives/friends/visitors in your village? [Y/N] *circle one*
25) If yes, has sharing your fish created **friendship/good relationship** with your neighbours/friends/visitors in your village? How would you agree?

0	1	2	3	4	5	6	7	8	9	10

0-strongly disagree 10-strongly agree

26) Tilapia farming violates your village **taboos/usual way of doing things**? How do you agree?

0	1	2	3	4	5	6	7	8	9	10

0-strongly disagree 10-strongly agree

27) Tilapia farming is an **additional commitment/burden** on top your usual gardening, off-farm employment, fishing, household chores, etc? How do you agree?

0	1	2	3	4	5	6	7	8	9	10

0-strongly disagree 10-strongly agree

28) Have you seen other farmers receiving benefits from their tilapia farms? [Y/N] *circle one*, if yes answer Q29
29) If yes, what benefits have you observed? List. _____
30) What are the reasons why tilapia is not taken up by interested or aspiring farmers in your same village, or other villages?
_____

Vulnerability context

31) What were some difficulties you faced when constructing your tilapia ponds?
_____
32) What were some difficulties you faced when looking after and feeding your tilapias?
_____
33) Overall, has tilapia farming improved your quality of life/wellbeing? [Y/N] If yes, how would you agree? (*explain wellbeing in the 5 common elements; basic material well-being; having enough for a good life, bodily wellbeing/health, social wellbeing/good social relations, security, freedom & choice.)*

0	1	2	3	4	5	6	7	8	9	10

0-strongly disagree 10-strongly agree

34) If no, what are some things that have affected your ability to achieve improved wellbeing from tilapia farming?
_____
35) In the last 12 months, have you experienced incidence of natural disasters that have affected your livelihood (*e.g. flooding, cyclone, fish mortality, etc*)? please list.

Natural disaster	*Impact on your household livelihood*	*What mitigation measures did you employ*

36) In the last 12 months, have you experienced anything else that has negatively affected your livelihood *(e.g. tilapia farm theft, sickness, lack of money, resources depletion, unfertile soil, etc)*? please list in the table below

Negative aspect	*Impact on your household livelihood*	*What mitigation measures did you employ*

Thank you so much for your time. We will use this information to better understand how tilapia farming is impacting livelihoods in Malaita

Sample interview form for non-tilapia farmers:

Farmer's demographic.

Age	
Gender	
Marital status	Married:_____ Single: _____

4) How many people are currently in your household?

Adult male	Adult female	Male children	Female children

5) Can you read or write? [Y/N] *circle one*

6) What is the highest level of education or training you have attained?

Highest level of education	Yes (√)
Primary school	
Secondary school	
Tertiary	
Vocational training (*specify what sort of training*)	
Others: (specify)	

37) Do you hold any position in your village or community (E.g. head of fishermen association, church minister, head of a committee, etc.)? [Y/N] *circle one*_____

38) Do you own the land here? [Y/N] *circle one*

39) If yes, is this the same land you cultivate? [Y/N], *circle one,* if no, who's land are you cultivating? _

40) What livelihood activities do you undertake to earn food or income for your household?

Livelihood activity	Food (√)	Income (√)	Income earned weekly	Expenditure on this activity per week (e.g. Labour, seed)	Average number of days (per week or month spent on this activity)	Rank in order of importance the 3 most important. ***1-most important, 2-important, 3-least important***	
						Food	Income

41) How much of the food produced by your household is consumed in your household?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%

6) Do you have access to? (circle or specify)

Household items & facilities	Lighting	Transportation	Cooking fuel	Roof material	Wall material	Floor material	Livestock
Generator	Nothing	Private vehicle	Firewood	Sago leaves	Sago leaves	Cement	Poultry/duck
Solar panel	Solar	Public vehicle	Charcoal	Iron roofing	Timber	Timber	Cattle
Water tank	Kerosene wick	Outboard motor canoe	Kerosene	Others (specify)	Palm planks	Palm planks	Piggery
Refrigerator	Flashlight	Dug-out canoe	Electric		Cement	Tiles	Goat
Electricity	Candle lit	Others (specify)	Others (specify)		Fibro	Ground/soil/earth	Others (specify)

DVD player/TV	Solar charged bulb lights				Metal	Others (specify)	

Solar battery Radio/stereo Mobile phone Flushed toilet Others (specify)	Others (specify)				Others (specify)		

Food security ***(I will use a card demonstrating the variety of food to aid with these questions)***

7) How many meals does your household normally eat in a day?

Number	**Question**	**Response option**	**code**
1a.	In the past week, did you or any household member have to eat a **limited variety** of foods because of difficulties with money, bad weather, other commitments, or no place to farm (or inability to fish)?	Yes No	|___|
1b.	How often did this happen?	Rarely *(once in the past week)* Sometimes *(twice or three in the past week)* Often *(four to five times in the past week)*	|_____|
2a.	In the past week, were you or any household member not able to eat the kinds of **foods you preferred** because of difficulties with money, bad weather, other commitments, or no place to farm (or inability to fish)?	Yes No	|___|
2b.	How often did this happen?	Rarely *(once in the past week)* Sometimes *(twice or three in the past week)* Often *(four to five times in the past week)*	|_____|
3a	In the past week, did you or any household member have to eat **fewer meals per day** because there was not enough food?	Yes No	|___|
3b.	How often did this happen?	Rarely *(once in the past week)* Sometimes *(twice or three in the past week)* Often *(four to five times in the past week)*	| |

8) What are the 3 most common animal protein that you & your household consume, apart from tilapia? _____

9) How frequently do you & your household consume this animal sourced protein?

	Daily	Weekly	Monthly	Annually
Option 1				
Option 2				
Option 3				

10) Where did you get the animal-sourced protein from? (indicate)

	Where (e.g., at local market, neighbour, Auki market, etc.)	Cost per daily or weekly (expenditure or if no cost)
Option 1		
Option 2		
Option 3		

Now, I would like to ask you some questions about tilapia farming.

11) Provide answers to the questions on the left under its potential sources of information (if there are multiple sources)

Have you received any information regarding tilapia farming?	Yes (*answer the questions in the table*) No (*skip to Q12*)								
Where did you get your sources of information from?	Friends	Relatives	Lead farmers	Newspaper	Pamphlets	Posters	Project officers	Radio	Others (specify)
Does this person have a tilapia pond? [Y/N]									
Location of the source *(e.g. where does the person live or where is the NGO located or is the newspaper local or national or is it a government extension agent provincial or national?)*									
How did you receive this information? ▪ *Word of mouth* ▪ *Written form (e.g. pamphlet, posters, pictures, etc)* ▪ *Radio* ▪ *TV* ▪ *Farm demonstration* ▪ *Others (specify)*									

Attributes of the innovation

12) What about tilapia pond farming makes you not interested in adopting it (e.g. construction, difficulty to access seeds, pond management, etc)? _____

13) Do you agree or not that tilapia farming violates your village **taboos/usual way of doing things**?

0	1	2	3	4	5	6	7	8	9	10

0-strongly disagree 10-strongly agree

14) Do you agree or not that tilapia farming is an **additional commitment/burden** on top your usual gardening, off-farm employment, fishing, household chores, etc? How do you agree?

0	1	2	3	4	5	6	7	8	9	10

1-strongly disagree 10-strongly agree

15) Do you agree or not that tilapia farmers are receiving benefits from their tilapia ponds? Y / N (*circle one) if yes answer Q14.*

16) If yes, what benefits have you observed? Can you give examples? _____

17) Have you observed some negative impacts from their tilapia farming in the village? _____

18) What are the reasons why tilapia is not taken up by interested or aspiring farmers in your same village, or other villages? _____

19) What do you think can be done further to facilitate a wider adoption of tilapia farming? _____

20) Will you ever adopt tilapia farming (now or future)? Y/N *circle one*

21) If yes, what would you need or require or needs to be met before you can adopt tilapia farming? _____

Vulnerability context

22) In the last 12 months, have you experienced incidence of natural disasters that have affected your livelihood (*e.g. flooding, cyclone, landslide, etc*)? please list.

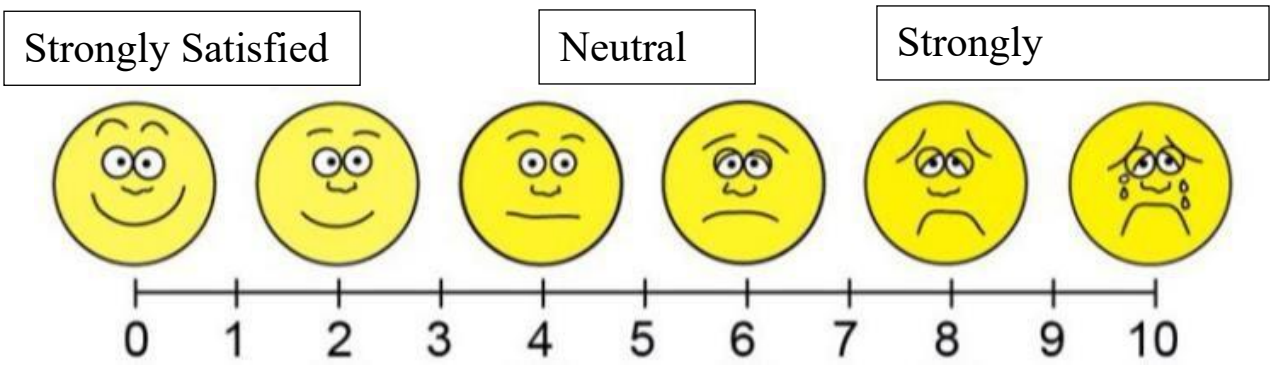
Natural disaster	*Impact on your household livelihood*	*What mitigation measures did you employ*

23) In the last 12 months, have you experienced anything else that has negatively affected your livelihood *(e.g. sickness, lack of money, resources depletion, unfertile soil, etc)*? please list in the table below

Negative aspect	*Impact on your household livelihood*	*What mitigation measures did you employ*

Thank you so much for your time. We will use this information to better understand how tilapia farming is impacting livelihoods in Malaita.

Likert-scale



Sample semi-structured interview form for institutional actors

I. Basic Information

Name of interviewee: _____

Name of Institution:

- Non-Government Organisation _____
- Faith-based Organisation _____
- Private company (sector) _____
- Government Institution _____

Position/title of interviewee within Institution; _____

What is your main role or responsibility within the organisation? _____

Years of experience with Institution; _____

- What is your institution's role in the development of rural tilapia aquaculture?
- What were the milestone(s) achieved to date by your organisation with regards to tilapia aquaculture development in the country?
- What has your organization learned about how to best support tilapia aquaculture?
- What are the constraints/barriers to developing rural tilapia aquaculture?
- How are these barriers addressed or will be addressed by your institution (or as a person in your role/responsibility)?
- Rural tilapia farmers (& interested farmers) have voiced that institutional support through 3 broad areas as lacking.
    - Incentives to assist existing & aspiring farmers (e.g. start-up funds, proper tools, or rural credit schemes)
    - Broader awareness to rural & remote communities, or through trainings & workshops.
    - Marketability of tilapia (note; farmers we met mostly perceive "benefits" surrounding rural tilapia farming as income earned from any form of its marketing, not so much on household consumption).
    - As an institution, what is your response or view on each of these areas?
- What are the opportunities (moving forward) for this rural fish production sector in the country?
- What is your institution's future plan for the advancement of rural tilapia aquaculture in the country?

APPENDIX 2: Data collection forms for households

Basic Demographics

1) Name of Household Head: _____
2) Name of village; _____
3) Sex of interviewees present: (Male household head ONLY/ Female household head ONLY/ Both) *(circle one)*
4) Tilapia adopting/non-adopting household: *(Circle one)*
5) GPS Position of Household dwelling: _____
6) Household demographic information.

Names of HH members	**Sex (M/F)**	**Position in household (*e.g. husband, child, etc*)**	**Age**

Household Food Consumption (24-hours recall)

7) If you can recall in the last 24-hours, what food did you and your household members consumed? Can you list them for me?

Instructions for Interviewers:

When asking food consumed by households, bear in mind, this will include:

- food prepared in the home and eaten in the home
- food prepared in the home and eaten outside the home
- food prepared outside the home and eaten inside the home
- It **DOES NOT** include food prepared outside the home and eaten outside the home.

It is important to probe for food eaten by ALL household members, even if ONLY one person consumes it, we must be able to capture this information

Activity: Free listing/open recall of food (*Also probe for fruits or nuts, or other foods consumed informally*)

Who: ask this question to the person responsible for preparing food in the household.

Materials needed: fish measurement cardboard

Instructions for filling-out the table:
In this exercise, please allow the respondent to freely list the food, before asking for frequency, source, size and etc.

- For any food **APART** from type of fish, **ONLY** ask and record the *name, frequency,* and *source* of food (no need to identify this source on the map). If **FISH** is mentioned (which include canned products), be specific on the fish name (*e.g. local name or common name, if unsure ask is it a fish from the reef, or deep ocean (pelagic), or river*).
- For the **SOURCE OF FISH TYPE** column, ask for the name of the source, but also let them identify this source on the map attached.
- Use **Q7** as the unique identifier for these sources on the map attached. *E.g. Q7-parrot fish, Q7-pelagic fish, etc. We will after the survey use Google map to obtain the distances (km) between households and their respective fish production sources, which will be inserted into the distance column (grey shaded).*
- For size of individual fish, use the fish measuring cardboard to help respondents estimate the length of the fish and record in centimetres, then ask how many pieces for the quantity. To record size of canned fish products, ask if it was a small-can (S), medium (M), or family-sized (L). *Necessary conversion will be performed on lengths and sizes of fish- types and multiplied by quantity to give the total weight (kg), which we will record later into the total weight column (grey shaded).*

So, note that the grey shaded columns will NOT be filled during the actual interviews, but after when we return each day from the field.

- If the interview is conducted in the morning, then refer to the recall period of 24-hours as the previous morning till current (same with afternoon, or evening), and be consistent with this for the rest of the other interviewed households. This is to overcome the fact that households don't necessarily think within exact time (e.g. what they consumed between 10am yesterday to 10am this morning), hence, enforcing this may restrict and jeopardise the data collected.

Name of food	*Frequency of consumption/day*	*Source of food (only identify source of fish on map attached)*	*Distance of HH from source of fish (km)**	*Size (cm)*	*Quantity (n)*	*Total weight (kg)**

**These columns will not be filled during the interviews.*

Household Food Consumption (seasonal variation)

Instructions for Interviewers:

Activity: Probe participants to describe the common/popular food types they consume during the different seasons.

Who: ask this question to the person responsible for preparing food in the household.

Instructions for qualitatively recording this:
Begin this question by asking what season they are in at the time of this interview (e.g. Is it now the wet, dry, or xx season?). Once, respondents have identified the season, probe what type of food they commonly consume during the present season (or is popular during this season). Then ask how this would compare to other seasons (e.g. dry or wet season) in Q8.

If ***fresh fish*** is mentioned, probe if its ***supply*** and ***consumption increase*** or ***decreases*** during this season, and where they ***source the fish*** from. However, if ***tinned fish products*** (tinned tuna, sardine, mackerel) is mentioned, just probe for the ***source***.

8) Now is the **dry/wet** season (identify this season from the Seasonal calendar); what common food do your household consume?

9) How does this compare to other seasons (e.g. **dry/wet** season)?

Household Animal-Sourced Food Consumption (7-days recall)

10) If you can recall in the last 7-days, which of these animal-sourced (meats) food did you and your household consumed?

Instructions for Interviewers:

Activity: Displaying of photo-cards of ALL MEATS consumed in Solomon Islands, and asking respondents to identify the meats consumed in the last 7-days.

Who: Both (husband and wife)

Materials needed: Fish measurement cardboard, photo cards of meat types, sheet of days of the week

Instructions for filling-out the table:

- Display the cards of animal-sourced meat on the table (or whatever flat surface you're using), then ask the household to recall in the last 7-days which of the meats they (household) have consumed in the last 7-days.
- To aid with the 7-days recall, the table attached can be used to guide the respondents through each day of the week, starting with the day of the interview and going backward. *NB: Also get them thinking about important days like sabbath, Sunday, etc.*
- Once they identify meats they've consumed in the various days of the week, then ask what food they ate it with the meat.
- For any meat apart from fish (including canned products), ONLY record the name, frequency of consumption, and source.
- If fish is mentioned, probe for the specific type of fish (e.g. bonito, saltfish, rabbit fish (*Muu*), tilapia, etc.), and probe further for its size and quantity.
- Apart from recording the source of fish types in the table, let the respondent identify this source on the map attached. This applies only for fish-meat *(use Q10 as the unique identifier in the map)*

Name of food	*Frequency of meat consumption/week*	*Source of meat production (identify on map)*	*Distance of HH from fish source**	*Size (cm)*	*Quantity (n)*	*Food eaten with the meat*	*Total weight of fish (kg)**

**These columns will not be filled during the interview, but later.*

Sex of household head interviewed: (Male/Female/BOTH) (*circle one*)

Preference Exercise

Instructions for Interviewers:

Activity: Displaying of photo-cards of ALL MEATS consumed in Solomon Islands, and asking the households to rank them according to taste, price, social prestige, and cultural/religious significance.
Who: BOTH male and female household head
Materials needed: photo cards of meat types

Instructions for filling-out the table:
Firstly, ask the household which meats from the cards they generally do not consume (put this aside from the rest of the animal cards).
Then ask what their reason is for not consuming these selected animal cards. Report this information in the left-hand column of the table below.

On displaying the remaining meat cards, ask the "household" to identify their preferred meats from the cards according to place the card in order of rank. You will do this exercise with them THREE separate times. FIRST for taste (*the most delicious, sweet meat on top*), SECOND price (*cheapest and affordable on top)*, THIRD social prestige (*accepted and highly regarded in any social occasion on top*).
You can do taste exercise first, then mix the cards again before the price and social prestige exercise.

11) Using these photo cards (of the various meats), can you exclude meat that your household don't consume? (*record response in the left corner of the table below*)

12) Why don't your household consume these meats? (*record this alongside the response in Q11 above*)

13) Can you rank the remaining cards according to its taste, price and social prestige?

Rank	*Taste*	*Price*	*Social prestige*	*Excluded meat types and the reasons why*
1				
2				
3				
4				
5				
6				
7				
10				
11				
12				
13				
14				
15				
16				
17				

18				
19				

9b). Wy did you ranked this way? *(referring to the table in Q13 and the specific meats ranked 1st across taste, price and social significance*)?

Taste:

Price:

Social prestige:

Proximity to usual market

Instructions for Interviewers:

This will be conducted in 2 parts; 1) part of the household interview, 2) Market observation

a. In the household interview, ask the household where their "USUAL" market is, and let them identify/locate it on the map attached.
b. Also, ask how frequently they visit the market?
c. If the household stated that their USUAL market is a village market (other than Auki market), then ask for how many times per week the market takes place?

2. Fish observation at the market;

The other part is to do a market observation. The things to do at the market are;

Check for fish availability at the market during the market days (as identified in the interview).
Record the types of fish sold, their quantity and estimate their size using the 60-centimetre ruler.

14) Where is the usual market your household go to, to buy food (fish included)? _____(*please identify this on the map attached*)

15) How many days in a week does this market operate? *(If Auki market is mentioned, then it is open 6 days/week)*

16) How often in a week do you (or any household member) visit this market?_____

17) How do your household access the market? (*e.g. public transport, bush path, private transport, OBM, dug-out canoe, etc.*)_____(*skip Q17b if it does not cost your household to travel to the usual market*).

17b: If you using paid transport to the market, how much do you spend per week going to the market?
_____

18) how long does it take to reach the market? _____

Observation at the market.

19) Record how many of the types of fish are sold per market day at the **USUAL** market, and estimate their length using a 60cm ruler. Permission/consent have to be obtained from the vendors before measuring their fish.

- Record this information in the table below. Divide this into production source (e.g. tuna, reef fish, freshwater fish, tilapia, so forth).

Days/week	*Reef fish*	*Size (cm)*	*Pelagic fish*	*Size (cm)*	*Freshwater fish*	*Size (cm)*	*Tilapia*	*Size (cm)*	*saltfish*	*Size (cm)*
Monday										
Tuesday									-	

Wednesday										
Thursday									-	
Friday										
Saturday									-	
Sunday										
TOTAL weight (kg) /week										

Additional questions.

Human Capital:

1. How satisfied are you on the fact that tilapia farming has increased your basic knowledge and skills on tilapia farming? (*e.g. knowledge on site selection, pond design, feeding, breeding of the fish, etc.*)

0	1	2	3	4	5	6	7	8	9	10

0 – Strongly satisfied, 5 - Neutral 10 – strongly dissatisfied

2. How satisfied are you with the level of fish contributed by your tilapia farming to your home for consumption?

0	1	2	3	4	5	6	7	8	9	10

0 – Strongly satisfied, 5 - Neutral 10 – strongly dissatisfied

Financial Capital:

1. How satisfied are you with the income obtained from your tilapia farming?

0	1	2	3	4	5	6	7	8	9	10

0 – Strongly satisfied, 5 - Neutral 10 – strongly dissatisfied

Social Capital:

1. How satisfied are you in that tilapia farming has expanded your local social network? (e.g. have you met new people via practicing tilapia farming, etc?)

0	1	2	3	4	5	6	7	8	9	10

0 – Strongly satisfied, 5 - Neutral 10 – strongly dissatisfied

Physical Capital

1. How satisfied were you on establishing and maintaining your ponds, based on the necessary tools and equipment you have available?

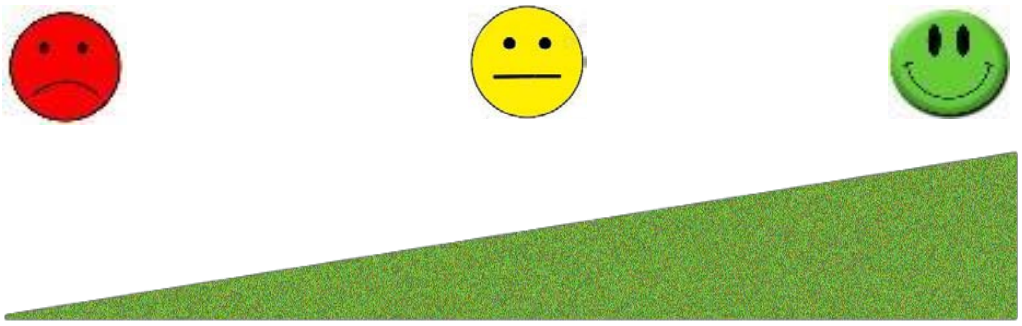
0	1	2	3	4	5	6	7	8	9	10

0 – Strongly satisfied, 5 - Neutral 10 – strongly dissatisfied

Natural Capital:

2. Apart from its contribution to household food consumption or income from sales, what other purposes had tilapia farming served your household? (*e.g. tilapia used for pig meal, or water from the ponds used to fertilise home food garden, etc.*) _____

Likert-scale



0 1 2 3 4 5 6 7 8 9 10

Strongly disagree — Strongly agree

Me barava no agree stret — *Me barava*