Adapting to climate change in Samoa's coastal fisheries: can policy frameworks and associated aquaculture initiatives make a difference?

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Abstract

Pacific Island countries are at the forefront of climate change, which is having a significant, detrimental impact on their coastal fisheries. The proliferation of extreme weather events, coral bleaching, and ocean acidification, paired with human-caused environmental degradation, is significantly impacting the sustainability of Pacific costal marine environments and resources. In Samoa, climate change and environmental degradation has put pressure on already struggling coastal marine environments and is depleting the country's coastal fish stocks. If this depletion continues, coastal fishery production will inevitably fall and further burden food security in Samoa.

Pacific regional and national frameworks such as the *2050 Strategy for the Blue Pacific Continent* and *The Samoa Ocean Strategy 2020-2030* are attempting to address these impacts, including through the introduction of aquaculture as a climate change adaptation mechanism. Samoa has recently trialled an aquaculture initiative that looks to revitalise limu (*Caulerpa racemose*) seaweed farming and is investing in a hatchery for Nile tilapia (*Oreochromis niloticus*) to support established but minor, freshwater fish farming efforts in Samoa.

Drawing on qualitative research methods and fieldwork in Samoa, and through employing an indigenous development theoretical lens, this thesis explored whether regional and national frameworks adequately address the needs of coastal fishing communities. It also investigated whether aquaculture initiatives for climate change adaptation can serve to counter depleting coastal marine resources, and therefore, serve as a viable adaptation solution for Samoan coastal fisheries.

The research revealed that, for the most part, regional and national adaptation strategies do integrate the needs of coastal fishing communities who bear the brunt of climate change and other environmental impacts. As a long-term adaptative mechanism for climate change and food security, however, there are divergent opinions on the viability of limu and tilapia farming to mitigate declining food security. In contrast, participants were all in strong agreement around the importance protecting traditional coastal fisheries by drawing on traditional knowledge and ecosystem-based adaptation measures. In the Samoan context, current aquaculture initiatives appear to lack scalability and fail to garner the cultural and social by-in to provide a viable strategy for enhancing food security.

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Excerpt: *Tell Them (2011)* from Marshallese poet Kathy Jetnir Kijiner

Chapter One: Introduction

1.1 Introduction and Overview

Climate change is widely regarded as the most prominent threat facing Pacific Island states (Govt. of Samoa, 2020). Climate change is expected to increase extreme weather, human health issues, disrupt water supplies, cause losses of biodiversity, disrupt economies and endanger food security (Bell et al., 2011). Rising sea levels threaten the very sovereignty of Pacific-island states who are bearing the disproportionate impacts of anthropogenic or human-made, climate change. In Samoa, climate change is already beginning to significantly impact coastal and subsistence fisheries, a crucial aspect of food security as most people in Samoa live near the coast and roughly 90% of locally sourced protein consumed in Samoa comes from the ocean (Govt. of Samoa, 2020). Like many other Pacific Island nations, Samoa has begun to implement polices to adapt to the increasingly severe impacts of climate change and environmental degradation in order to sustain vital marine resources.

This research will use indigenous development as a conceptual framework to explore the institutional and national responses which are being deployed to ensure the sustainability of Samoa's indigenous fishing industry. Several adaptation and mitigation plans have been developed and put into action in recent years. This research will question whether national responses such as the Samoan Ocean Strategy 2020-2030 are connected (or disconnected) to the needs of people within the indigenous fishing industry and those most impacted by the effects of climate change and environmental degradation.

Within many of these strategic framework's, aquaculture has been consistently put forward as an important adaptation strategy, particularly for food security. Samoa's aquaculture sector is extremely limited and has been largely neglected due to cultural and environmental reservations (Toeolesulusulu Cedric Schuster, 10 October 2023). However, in recent years, resources have been applied to develop this fledgling industry which has produced some

promising results. The culturing of Nile tilapia (*Oreochromis niloticus*) and seaweed or limu (*Caulerpa racemosa*) have both been widely recognised as an important climate adaptative mechanism (Tiitii, 2021). In collaboration with the government of Japan, 2021 saw the limu revitalisation project kick off an effort to establish 20 limu (seaweed) plantations across the two main islands of Samoa. The traditional food source can be harvested and farmed with relative ease and is considered highly nutritious containing a range of minerals. In addition, harvesting limu provides an opportunity to restore traditional methods of aquaculture and adhere to culturally appropriate farming practices (Tiitii, 2021). This project culminated in the construction of the Toloa hatchery, an aquaculture facility built to culture limu and tilapia for local communities. Previous attempts to commercialize and upscale the harvesting of limu and tilapia have been unsuccessful but, Samoan aquaculture now appears to be gaining momentum. This research will be questioning the viability of Samoan aquaculture as adaptation solutions and ask whether these small initiatives can alleviate the pressures on Samoa's coastal marine resources.

1.2 The Samoan indigenous fishing industry

In the context of this research, I have used the term 'indigenous fishing industry' to describe people fishing in coastal marine areas, using traditional methods, for either subsistence or income. This therefore excludes any fishing done beyond the reef and for export purposes. In Samoa, the vast majority of people involved in fisheries source their catches from the within the fringing reef as they have done for centuries (Gillett & Fong, 2023). These coastal marine environments are highly susceptible to the impacts of climate change and environmental degradation which leaves those who rely upon its resources extremely vulnerable.

1.2 Background/Rationale

Pacific Island countries are on the front line of climate change (Barnett & Campbell, 2010; Bell et al., 2016; Bettencourt et al., 2006; Latai-Niusulu, Binns & Nel, 2020; Mcleod et al., 2018; 2019). Strategies to adapt to its impacts are well reflected in Pacific development policies and strategies such as the Aotearoa New Zealand International Climate Finance Strategy (Govt. of

New Zealand, NZ, 2022), the Samoa Ocean Strategy (Govt. of Samoa, 2020) and the 2050 Strategy for the Blue Pacific Continent (Pacific Island Forum Secretariat, 2022).

Pacific Island leaders have long stressed the importance of indigenous/local approaches to climate change adaptation (Bryant-Tokalau, 2018; Govt. of Samoa, 2022; McMillen, et al., 2014; Pacific Island Forum Secretariat, 2022). While most institutional level strategies make mention of the value of traditional and indigenous and local knowledge as part of the solution, what remains a challenge is ensuring local people's realities and indigenous ways of thinking and doing are actively included or privileged (Barnett & Campbell, 2010; Bryant-Tokalau, 2018; Mcleod et al., 2019), and that institutional solutions are not disconnected from the lived experiences of those most affected by the impacts of climate change. Using the case study of Samoa and indigenous fishing, my research aims to understand this situation in more detail by investigating what is planned in climate change and fisheries at the institutional policy/strategy level and what is happening and needed by local people.

This is important as caring for the Pacific Ocean is critical for supporting sustainable livelihoods for the people of the Pacific. In Samoa, the Indigenous fishing industry is essential to the survival of thousands of Samoans as ocean proteins account for around 20% of the local diet. Coastal fishers utilise over 500 species of fish for consumption and income (Food & Agriculture Organization, FAO, 2018). In addition, Samoans hold deep spiritual and cultural connections with the ocean. The impacts of climate change are threatening this identity and depleting critical coastal marine resources. A myriad of adaptation and mitigation frameworks for Samoan fisheries have been assembled in recent years to combat the impacts of climate change and environmental degradation. Comprehensive plans for Samoa's oceans such as the Samoa Ocean Strategy (SOS) 2020-2030 are beginning to address these issues, but it is unclear whether these polices are making a positive difference to Samoa's indigenous fishing industry.

Aquaculture is a regularly suggested strategy for climate change adaptation in the Pacific fisheries sector. The depletion of coastal marine resources as a result of climate change and environmental degradation is creating a significant demand for alternative food sources (Govt. of Samoa, 2020). Aquaculture has been identified as adaptative mechanism for climate change and is a sustainable strategy that can be implemented at a grassroots level (Airu, 2021). Samoa's existing aquaculture industry is extremely limited, and exploring the potential for

bolstering and expanding the industry may be vital for Samoa's indigenous fishing industry. Recent efforts to cultivate limu (seaweed) and Samoa's fledgling freshwater fish industry will be the primary focus of my exploration into Samoa's aquaculture sector.

This research will contribute to the growing body of Pacific knowledge focused on locally/Indigenous led ways to improve climate resilience and adaptation (Bryant-Tokalau, 2018). A key priority as also identified by many Pacific Island scholars (Carter, 2015; Goulding 2016), and Pacific-focused organizations and regional bodies and governments (Caritas, 2014; Govt. of NZ 2022; Govt. of Samoa, 2020; Pacific Island Forum Secretariat, 2022). As mentioned, development plans such as the Aotearoa New Zealand's Climate Finance Strategy (Govt. of NZ, 2022), and the Samoa Ocean Strategy (Govt. of Samoa, 2020) argue it is important to build resilience and adaptation capability through Indigenous-led climate change projects that utilize and recognise local/Indigenous knowledge.

1.3 Research Aim and questions

This research aims to examine the strategies used by Samoa's indigenous fishing industry to combat the adverse impacts of climate change and explore the viability of aquaculture as an adaptation strategy. Through an indigenous development lens, this research will explore the institutional responses to the impacts of climate change on Samoa's indigenous fishing industry and will attempt to discern whether there is a disconnect between national adaptation policies and what is needed at the local level. This research will also investigate the viability of aquaculture as an adaptation strategy and specifically, the culturing of Nile tilapia and recent efforts to revitalize Samoa's limu (seaweed) industry. This research will question whether these aquaculture sources can replace or at least partially replace depleting sources of coastal marine species and thus, be classified as viable adaptative mechanism for climate change and environmental degradation.

Research Questions

The following two questions will be answered through this research.

1. *Is there a disconnect between Samoan national adaptation frameworks for fisheries (such as the Samoa Ocean Strategy 2020-2030) and what is needed by those most impacted (Samoa's indigenous fishing industry) by climate change and environmental degradation?*

2. *Is aquaculture a viable adaptation strategy for Samoa's indigenous fishing industry?*

1.4 Chapter outline

Following this introductory chapter, chapter two will begin with an overview of my conceptual framework, indigenous development, and application of this conceptual framework to my research topic. Chapter two will then outline the strategic context for my research by chronicling the climate change adaptation strategies for the fisheries sector in the Pacific region, as well as the impacts of climate change on Pacific Island countries. Chapter two will also discuss the use of aquaculture and will look at case studies from across the Pacific region as well as analyse aquaculture within the context of climate change.

Chapter three will focus on Samoa. This chapter will begin with an exploration of Samoa's oceans and the cultural and spiritual connections of Samoa's people to the sea. This will be followed by an examination of Samoa's indigenous fishing industry and its role in Samoan society, culture, and economy. Chapter three will then discuss the industry in the context of climate change and examine the impacts of climate change and environmental degradation on indigenous fisheries. This chapter will then outline a case study of national adaptation frameworks for fisheries that have been developed over recent years to mitigate and adapt to the impacts of climate change. Finally, chapter three will examine Samoa's fledgeling aquaculture sector and its potential as an adaptive measure.

Chapter four will address my chosen methodology. I will outline my qualitative approach and choice of research strategies and techniques. Chapter four will also discuss my research in

practice, including my positionality and they way in which my connections and upbringing impacted my fieldwork in Samoa.

Chapter five will begin to describe my findings and will address research questions one and two. This chapter will present the findings of in-depth four interviews conducted with key stakeholders and leaders in Samoan fisheries and development. The findings will be presented in a narrative style and will be presented by each research question and sub-questions.

The final chapter will discuss the last of the findings which lead into the conclusions on each research question. This chapter will analyse the findings of research questions one and two and attempt to provide answers for each. Chapter six will conclude with some final reflections on this research namely that current adaptation framework adequately addresses the needs of Samoa's indigenous fishing industry because of their extensive consultation period within coastal fishing communities. Aquaculture as an adaptation strategy is an important tool for adaptation, but economic, social and cultural limitations inhibit the viability of aquaculture as an adaptation solution for Samoa's indigenous fishing industry. Chapter six concludes by recommending that a combination of aquaculture initiatives and ecosystem-based adaptation is needed to ensure the sustainability of Samoa's coastal marine environments and resources.

Chapter Two: Climate change and fisheries in the Pacific region

2.1 Chapter introduction

This chapter will introduce the theoretical lens of this research, indigenous development, and its connection to fisheries throughout the Pacific region. Following this, the impacts of climate change and environmental degradation on the region and the fishing industry will be described to provide context on the underlying crisis driving development efforts in the Pacific fisheries sector. The materialisation of these development efforts, regional adaptation plans, strategies and policies will be explored and the extent to which they include indigenous knowledge, will be analysed. Finally, this chapter will finish by discussing aquaculture (specifically limu [seaweed] and tilapia culturing) as climate change adaptation mechanisms for fisheries in the Pacific region.

2.2 Indigenous development

Indigenous development stems from alternative development and post-development theories which were formulated as a reaction to the failings of modern, orthodox development practices (Sidaway, 2014). Post-development, and by extension indigenous development theories, rejects conventional, western-based development discourses such as modernisation and dependency theory and in an overarching sense, seeks to re-think the definition of development (Escobar, 1997). Post development thinkers argue that development has become a western religion intent on homogenisation that is fundamentally reductionist and enforces power imbalances that create the very inequalities that development practices seek to abolish (Sidaway, 2014). These theorists believe that conventional development manifests the interest of the ruling elite who hide their agendas within development policy. These same agendas promote western economic, cultural, and moral superiority while disregarding, shunning, and devaluing non-western

ideologies. These ‘normal’ development approaches deliver development from the top-down, reinforcing inherently unequal relationships and disenfranchisement. This process has created ‘under development’ in the Global South (Escobar, 1997). Alternative development thinkers theorise that mainstream development under a global hegemonic neoliberal economy cannot conceptualise and reconcile the blend of physical resources with social and cultural resources. Thus, mainstream development is unable to acknowledge the importance of social and cultural resources and is unable to deliver/replace physical resources that have been looted over centuries of colonialism (Macneill, 2020, pp. 270–290). In simple terms, mainstream development is concerned with capital and economic gain rather than wellbeing.

Indigenous development holds many of the same core principles of alternative and post development. Indigenous development approaches are marked by grounded approaches rather than the overarching, sweeping practices of mainstream development theories. Indigenous development theory values the voices of indigenous peoples (Nursey-Bray & Palmer, 2018). A bottom-up approach to development underpinned by indigenous ways of knowing allows for indigenous development practices to identify local vulnerabilities that can be acted upon by local stakeholders who become participants rather than subjects (Nursey-Bray & Palmer, 2018).

Indigenous peoples can self-identify their assets and relative strengths rather than their needs and act accordingly. This self-identification allows for a seamless integration of traditional knowledge into catered development solutions (Nursey-Bray & Palmer, 2018). Indigenous development is not concerned solely with the physical but of the social, political and cultural and they ways in which to build the capital of these respective areas. Building the capital of these areas paves a way toward equity and justice and creates a ‘seat at the table’ for indigenous peoples (Macneill, 2020, pp. 270–290).

In addition, because of the immense amount of indigenous knowledge surrounding ecology, indigenous development plays an important role in the protection of the flora, fauna and the environment as a whole (Doffana, 2005). Indigenous people’s close affinity to nature has helped indigenous groups develop a wealth of knowledge including an understanding of subtle ecological processes, diverse ways to utilise resources and the means to manage and conserve natural resources. This traditional indigenous knowledge of nature built over centuries can be incredibly detailed and subtle and on equal footing with modern scientific knowledge (Doffana,

2005). As this research will reveal, indigenous knowledge built into indigenous development practices is important for Pacific development particularly in an era of climate change.

2.3 Indigenous knowledge, Pacific fisheries, and Climate change

Pacific Island Countries and Territories (PICTs) have for centuries, thrived despite their incredibly isolated geography and finite resources. Much of this prosperity can be attributed to a deep connection to the natural environment and the maintenance of indigenous knowledge, passed down through generations. Indigenous peoples of PICTs compliment their natural environment and culturally imbed the conservation of their environments, both land and sea (United Nations, 2023).

In the present day, indigenous peoples of the Pacific are adapting to climate change using indigenous knowledge and customary practise to enhance their resilience toward climate changes impacts (United Nations, 2023). Examples of the employment of indigenous and traditional knowledge (TK) are numerous across the Pacific region. In the Solomon Islands, the Babnakira people use their knowledge of seasonal weather patterns to predict and build resilience ahead of extreme weather events. The Babanakira people also use regenerative environmental techniques such as planting native species on hillsides and cultivating a variety of crops to ensure that they can quickly recover following cyclones, landslides, floods, and other extreme weather events (United Nations, 2023). In the Torres Strait islands, communities are responding to increasingly erratic and severe weather events by distributing and diversifying crops on different areas of land to ensure crops are not all affected by the same weather events. The extensive knowledge of soils and specific fertile areas needed to implement these practices is shared between communities for mutual benefit.

In the realm of Pacific fisheries, TK plays an important role. For centuries Pacific islanders have relied upon the sea for substance and have passed down, largely through oral transference, TK on the harvesting and management of marine species (Kitolelei et al., 2021). Conservation of marine resources is a common theme among Pacific Island states. Customary management systems which include practices such as no fishing during spawning, mating season and after the death of a chief, restrict fishing areas, restricting fish sizes that can be taken and freeing

some of the catches were and still are, utilised throughout the Pacific (Kitolelei et al., 2021). Measures such as the above mentioned were often used where fishers were aware of their limited resources and knew to accumulate resources for the future (Kitolelei et al., 2021). Additionally, traditional fishing gear such as fish gorges would ensure that fishers only caught what they needed. In Hawai'i, the Kānaka Maoli (indigenous Hawaiians) are rebuilding traditional food systems that can better withstand the impacts of climate change. For 600 years the Kānaka Maoli used fishponds and the natural patterns of watersheds to culture a steady supply of fish. Each pond can provide thousands of fish and have no impact on surrounding environments (Kitolelei et al., 2021).

In Samoa, TK is used to harvest the delicacy palolo. Palolo is a reef worm that spawns and is harvested on the 7th day after the full moon. The waning moon induces spawning which releases the eggs and sperm from the 'tail' of the worm and is collected during the night by fishers (Caspers, 1984). The spawning is marked by the Mali'o crab which will descend into the sea prior to the release of palolo's reproductive cells (this phenomenon can be witnessed in Fiji also). Coastal communities also consider the wind, weather systems and tide to decide on the exact time to harvest. Sunlight destroys the 'tail' of the worm, so timing of the harvest is critical (Caspers, 1984). Palolo would be referenced by participants of this research several times as yet another example of the crucial nature of indigenous knowledge in the fisheries sector. The importance of this indigenous knowledge is becoming increasingly accepted into development practices throughout the Pacific particularly in the realm of climate change leading it to be included in a number of regional and local adaptation plans.

2.3.1 Indigenous development and fisheries in the Pacific

Indigenous development practices can be seen across the Pacific region. Samoa has been a proponent of indigenous development through its unique international tourism sector. Beach *fales,* small open-air huts, dot much of Samoa's beaches rather than large, resort style hotels. Samoa's' tradition of customary land management, and a culture of independence ensures that it's beaches and *fales* remain under village ownership and foreign investment from multi-national cooperations is discouraged (Scheyvens, 2004). As a result, local wealth is preserved, and local culture is respected (Scheyvens, 2004). In Fiji, indigenous development is used in

response to natural disasters. This is illustrated by solesolevaki, a traditional concept that promotes people working together without monetary incentive to achieve a common goal. Solesolevaki promotes social capital and a shared sense of community linking to indigenous development values such as collective wellbeing (Vunibola, & Scheyvens, 2019). Solesolevaki has been applied to improving education, village infrastructure, health outcomes and overall wellbeing. The concept has been utilised on the outer Fijian island of Kadavu as a disaster management technique and a climate change adaptation mechanism. In the wake of cyclones and other natural disasters, rural villages in Kadavu use solesolevaki to rebuild and rehabilitate. Examples of ingenious development techniques such as the above mentioned are widespread among the Pacific region and like indigenous knowledge, are becoming the normalised for climate change adaptation strategies particularly in the fisheries sector.

2.4 Pacific Fisheries

The importance of the fisheries sector to PICTs cannot be understated. Whether from a cultural, social, economic or wellbeing perspective, fisheries in the Pacific are integral to the prosperity of nearly all PICTs. Across 22 PICTs the fisheries and aquaculture sector produce 1.6 million tonnes of fish worth 2.5 billion USD annually, roughly half of New Zealand's equivalent sector value (Gillett & Fong, 2023). The bulk of the sector (in economic value) consists of offshore fisheries (87%), fish caught beyond the reef but within the 200-mile Exclusive Economic Zone (EEZ) of each respective state. Coastal fisheries, make up 11% and freshwater fisheries 1-2%. Importantly, of the 11% of coastal fisheries, 8% can be attributed to subsistence fishing (the indigenous fishing industry in the case of this research) (Gillett & Fong, 2023).

Although only 8% of the fisheries sector catch is caught through subsistence fishers, the number of people involved in the indigenous fishing sector outweighs that of the commercial sector. In Oceania, a 2016 report found that up to 1.3 million people partake in subsistence fishing compared to 530,000 in the commercial sector, a significant statistic when compared to the Americas where just 700,000 fish for subsistence and 3.6 million fish commercially (Gillett & Fong, 2023). This significant inversion paired with the fact that the America's population dwarfs Oceania is another testament to the importance of the indigenous fishing sector in the region. Oceania is one of the only regions in the world where the number of people involved

in subsistence fishing outweighs those in the commercial sector (see figure 2.1) (Gillett & Fong, 2023).

Domestically, fisheries provide a vital source of household income across the Pacific islands. In the tuna industry alone, 12,000 people are employed in canneries in Fiji, Marshall Islands, PNG and the Solomons. In the coastal fisheries sector, hundreds of thousands of people generate income through small scale fishing enterprises. Surveys by the South Pacific Community (SPC) have found that across 17 PICTs, 47% of all coastal households earned their first or second income from the selling of marine species which they caught (Bell et al., 2011). These small enterprises included the selling of surplus catches, selling of delicacies to export markets and contributing to ornamental trade (Bell et al., 2011).

Fish are not only important for PICTs economically but are a cornerstone of food security in the coastal Pacific. In PICTs, coastal fishing provides the vast majority of fish for consumption (Gillett & Fong, 2023). Subsistence fishers harvest hundreds of different species and the catch, caught within the fringing reef, can range from large sharks to tiny invertebrates. In most PICTs, coastal fisheries account for at least half of fish production (see figure 2.10. In Kiribati and Tuvalu, which boast among the highest rates of fish consumption in the world, coastal fisheries are doubly crucial as these states have zero offshore fisheries production (Gillett & Fong, 2023). This high level of fish harvesting means that coastal and rural populations typically consumes between 47.3-126.3 kg of fish (calculated average) per person, per year across Micronesia, Melanesia and Polynesia.

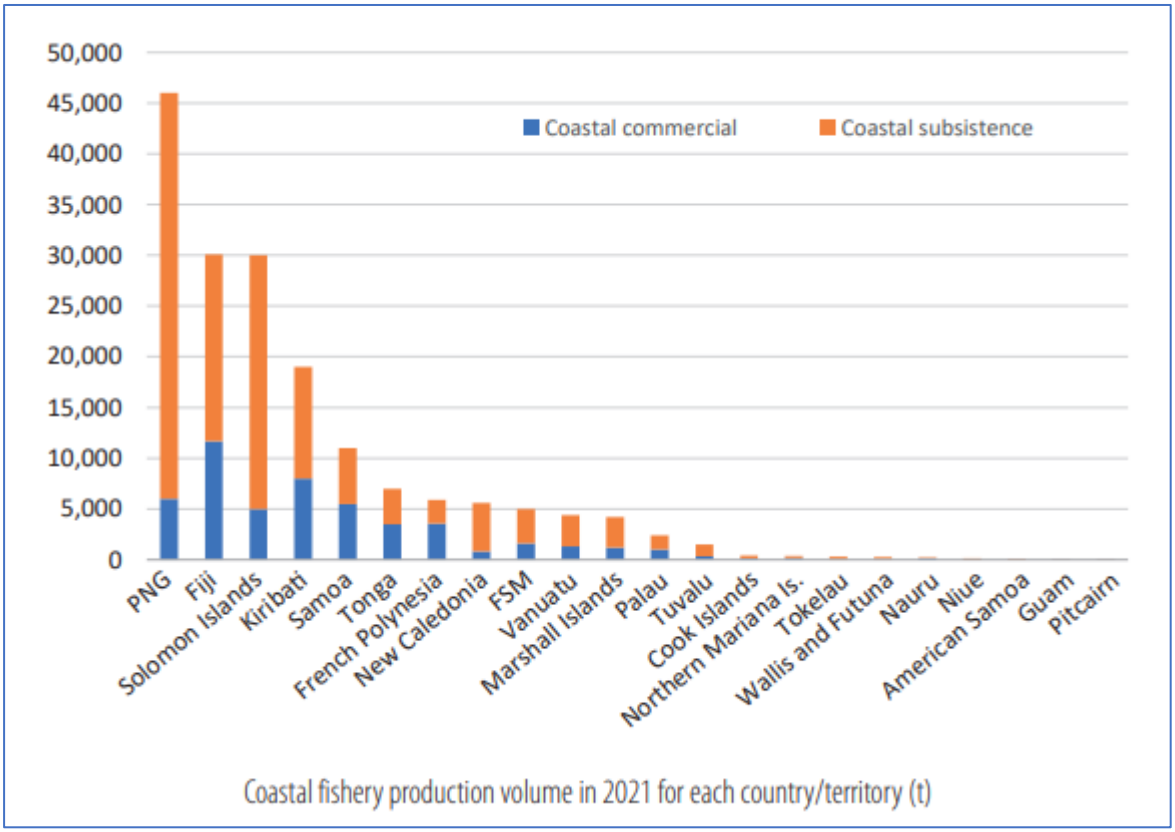

Figure 2.1, Source: (Gillett & Fong, 2023)

Urban centres also tend to greatly exceed the global average of fish consumption of 16-18 kg per person, per year (Gillett & Fong, 2023). In addition to food security, fisheries are incredibly important and are intertwined within cultural, social and spiritual practise and traditions of PICTs (this will be discussed further in chapter three). With such a heavy reliance on coastal fisheries, serious concerns have come to light regarding the future capacity of coastal fisheries to meet the supply needed for food security among PICs. At least a 47% increase in fisheries production is needed to meet the minimum needs of nutrition for Pacific islanders by 2030 (Gillett & Fong, 2023). This daunting requirement is opening the door to alternative fish harvesting methods such as aquaculture (Bell et al., 2011).

2.4.1 Pacific aquaculture

In stark contrast to traditional fishing practices, aquaculture production among PICTs is extremely limited. In 2021, aquaculture production in the Pacific was valued at 85 million USD and accounted for 3.4% of all fisheries in the region (Gillett & Fong, 2023). However, two French territories were responsible for 88% of all aquaculture value (largely due the French Polynesian pearl farms). Across the region, only five PICTs have an aquaculture industry worth over half a million USD and only 11 of 22 PICTs have an industry that can be considered significant (worth over 50,000 USD). Across the board there is a distinct lack of knowledge regarding aquaculture among PICTs which extends to the indigenous fishing industry (Gillett & Fong, 2023).

2.5 Climate change and fisheries in the Pacific

Over the past two decades PICTs have become synonymous with climate change and its effects. These impacts threaten environments, economies, food and water security, health, and even sovereignty (Mcleod et al., 2019). Since 1900, the average sea surface temperature has increased by 0.7 °C and is projected to rise by 1.2-1.6 °C by 2050 and 2.7°C by 2100 under high emissions scenarios (Johnson et al., 2018). This rise in temperature will generate a myriad of complex impacts. Through thermal expansion and the meting of land ice, the warming sea is slowly rising, and its ocean currents are changing. Warmer seas reduce the vertical mixing of nutrients in the upper portion of the ocean which is hindering the production of the base layer of fisheries food chains (Johnson et al., 2018). Warmer waters are also increasing the intensity of the hydrological cycle causing extreme weather patterns and increasing the severity of tropical cyclones (Bell et al., 2011).

The proliferation of greenhouse gases in the atmosphere (the underlying driver of climate change) is also increasing oceanic concentrations of carbon dioxide (CO2). The Earth's oceans have absorbed 30% of all CO2 since the industrial revolution which has caused a significant rise in ocean acidity, so significant that the oceans are more acidic now than in any other period within the last 800,000 years (Bell et al., 2011). CO2 combines with sea water to create carbonic acid. This acid dissolves carbonate required by marine species to form shells and

skeletons thus threatening the survival of thousands of marine species (Bell et al., 2011). With enough CO2, Earth's oceans may reach a tipping point where environments favour the dissolution rather than formation of organic carbonate materials (Bell et al., 2011). These big-picture impacts of climate change are each undermarked by multiplier of further impacts that seriously threaten fisheries in the Pacific Ocean.

As mentioned earlier, changes to water temperature and oceanic currents are creating serious implications for the distribution and reproduction of coastal fish species. Warmer waters are driving fish species towards the poles, causing latitudinal shifts among certain species, and expanding nutrient-poor zones which fish avoid. Changes to ocean currents are also altering the distribution of fish larvae and disrupting the replenishment of certain habitats (Gillett & Fong, 2023). For nations with restricted EEZs, these shifts cause an obvious problem. Additionally, fish reproduction is highly sensitive to fluctuations in temperature. Higher temperatures may affect the mortality of fish eggs, reproductive windows and distribution, reduced fertilisation and extreme vagary among fish larvae (Bell et al., 2011). Overall, implications of these impacts on Pacific fish populations are still relatively uncertain and will likely become a larger issue in the longer term.

In the short-term, an area of significant concern is the impact of climate change on coral reefs and coastal marine environments. Coastal fish depend on coral reefs for survival. As habitats that provide both food and shelter, coral reefs are the epicentre of marine life along the coasts of PICTs. These crucial reefs are now being degraded through coral bleaching, a reduced capacity to grow and repair skeletons due to lower levels of carbonate and damage through severe cyclones and other extreme weather events (Johnson et al., 2018). Coral bleaching is causing havoc among Pacific reef systems and destroying coastal habitats in swathes. Eventually, continued loss of coral reefs will completely alter coastal fish populations and may lead to an ecological take-over of herbivorous fish that feed on (soon to be abundant) heat-resistant algae that will grow on dead reef systems (Johnson et al., 2018).

These current and predicted impacts will have numerous detrimental implications for Pacific fisheries. Changes in the distribution of fish will force deep-sea fishers to travel longer distances and, in some cases, cease operations as species move out of EEZs. Species such as skipjack and bigeye tuna are likely to move further east, away from traditional fishing zones.

Catch sizes may also vary as reproduction patterns of target species become sporadic (Johnson et al., 2018). Among coastal fisheries, declining coral reefs will severely impact reef fish, resulting in lower yields and a reduction in key species which will place pressure on food security. Additionally, coastal fishers will face an alarming new threat that is, the reduction in value of TK. Changes to natural coastal environments and the distribution/abundance of key species will erode the benefits of TK on fish harvesting (Johnson et al., 2018). Significant changes to fish behaviour patterns and a disruption to traditional food webs may eventually render much TK irrelevant which would have severe implications that extended beyond fishing for the sake of consumption.

Compounding the above threats to Pacific marine species and Pacific fisheries is the fact that any change in fish abundance by climate change will be overshadowed by the overexploitation of those same fish (Gillett & Fong, 2023). Overfishing and environmental degradation are currently causing declines in marine life much faster than climate change. Overfishing is an issue that extends back to the end of the second world war when global powers began to fish the South Pacific on an industrial scale (Field, 2021). Immense longliners with up to 3000 hooks are used to pull in huge catches of pelagic fish such as tuna. In recent years and having exploited their own waters, China has moved into to the South Pacific with over 290 vessels, but it is suspected that many more fish illegally (Field, 2021).

Although this type of fishing is largely detrimental to deep-sea species, coastal fisheries experience the same threats of overfishing. Growing populations and an increasing demand for coastal fish species is putting pressure on already vulnerable ecosystems. In conjunction with other sources of environmental degradation such as invasive species and pollution, coastal fisheries are in an extremely precarious position. Considering these threats and with the impacts of climate change becoming more apparent, international organisations have sought to produce adaptation solutions for Pacific fisheries to ensure the viability of this crucial resource.

2.6 Regional adaptation plans

Much action has been taken to the protection of Pacific Ocean resources in the face of climate change and environmental degradation. The obvious and crucial need to protect the marine resources of the Pacific has led regional bodies, international organisations, Non-government organisations (NGOs) and nation states to collaborate and produce a number of climate change adaptation policies for the Pacific fisheries sector.

The need to address climate change in the Pacific can be traced back to the 1990s where frameworks such as the Stress Response Methodology, a climate response plan was developed by South Pacific Regional Environmental Program (SPREP) and Japan (Hay, 2011). Other early adaptation plans included the IPCC's Common Methodology and the internationally recognised Kyoto Protocol, which included an adaptation plan for the South Pacific (Hay, 2011). These early strategies predominantly favoured a top-down approach and often failed to recognise underlying vulnerabilities and variables (Hay, 2011). Strong influence from international development partners ensured that climate change adaption was in alignment with mainstream, development approaches. In more recent years, acknowledgement has been made toward the value of bottom-up and grassroots approaches to climate change adaption. Listening to the needs and issue of those most impacted by climate change has begun to steer the direction of climate change adaption toward alternative strategies that value and apply indigenous knowledge to adaptation polices (Hay, 2011).

The 2050 Strategy for the Blue Pacific Continent is a Pacific regional policy aimed toward the governing and safeguarding of the Pacific Ocean and its resources over the next half century with the issue of climate change included as a key thematic area. The 2050 strategy produced by the Pacific Island Forum Secretariat (PIFS) and endorsed by Pacific leaders, is an example of the new wave of climate adaption policy that address the needs of those most impacted by climate change and serves as a broad guideline (2050 Strategy for the Blue Pacific Continent, 2022). On paper, the 2050 plan looks to ensure the inclusion of TK within climate change adaptation protocols. Whether this 'strategic pathway' is observed is of course an aspect of first question of this research. Recent regional frameworks such as the 2050 Strategy for the Blue pacific Continent tend to include and acknowledge the importance of TK and the needs of those

most impacted by climate change. However, at the village level, this connection between policy and the everyday reality of those bearing the impacts of climate change is not always obvious, and hence is the subject of this research (see chapter five).

2.8 Aquaculture as an adaptation strategy in the Pacific region

Aquaculture has often been put forward as an adaptative mechanism for climate change. As mentioned in section 2.4, aquaculture production in the South Pacific region is currently extremely limited but its potential is now being recognised. The WWF -Pacific Sustainable Fisheries and Seafood (SFS) Programme Manager, Duncan Williams is quoted as saying that developing sustainable aquaculture may relive pressure on coastal fisheries and improve food security (WWF, 2021). As mentioned in section 2.4.1, the bulk of aquaculture production in the Pacific is not associated at all with consumption, climate change or food security. Pearls, specifically pearls produced in French Polynesia, are responsible for over two thirds of the value of aquaculture across the entire South Pacific region (see figure 2.4) (Gillett & Fong, 2023). However, other forms of aquaculture are quickly expanding, and the culturing of these species are often providing more than just economic gain.

The leading aquaculture activities in 2021

Activity	Value of production (US$ millions)
Pearls in French Polynesia	50.2
Shrimp in New Caledonia	18.5
Shrimp in French Polynesia	3.2
Tilapia in PNG	2.4
Seaweed in Solomon Islands	1.9
Pearls in Fiji	1.4
Tilapia in Fiji	1.0

Figure 2.4 South Pacific aquaculture production Source: (Gillett & Fong, 2023)

As seen on figure 2.4, Tilapia is one of the larger forms of aquaculture in the South Pacific. Nile tilapia (*Oreochromis niloticus)* commonly referred to as just tilapia, is a small, freshwater fish native to Africa and the Middle East (Maiava, 2019). Tilapia has been called "the food fish of the 21st century" and is the most farmed freshwater fish species in the world. Tilapias are a hardy and versatile fish and can adapt to a wide range of environments which has led to the culturing of tilapia across 135 countries (South, et al., 2012). In addition, tilapia is fast growing, can live in crowded areas, can survive in brackish waters, are disease resistant (they do not require any chemicals or antibiotics), can be fed on a cheap vegetarian diet and importantly, can withstand an almost extreme range of temperature (tilapia can live comfortably between 8 and 42°C) (South, et al., 2012).

The tilapia was first introduced into the Pacific region in the 1950s for its low-cost and successful production in other regions. The species are farmed largely via pond culture and in Fiji, are integrated into the farming of sheep, ducks and chickens which promote the growth of algae which in turn, feeds the tilapia (South, et al., 2012). In Melanesia, the availability of freshwater and acceptance of tilapia as a food fish has led the culturing of tilapia to be established as both a subsistence food source and a commercial product. The culturing of tilapia in Fiji is so efficient that it within a 500m2 size pond (less than half the size of an Olympic swimming pool) a yield of 500kg of fish can be harvested every 4-5 months (Bell et al., 2011).

The potential for tilapia as an adaptative mechanism for climate change are obvious. Where there is an ability to culture the species, subsistence fishers, indigenous fishers and communities can have access to a reliable and consistent food source that can survive much of the effects of climate change. However, although the culturing of tilapia is growing in popularity there are several roadblocks preventing the fish from becoming a viable strategy for climate change adaptation in the fisheries sector. Similar to the overarching and all-encompassing policies of the 2050 Strategy for the Blue Pacific Continent, tilapia as an adaptation strategy look extremely beneficial on paper, especially for subsistence fishers but, environmental concerns, cultural and social norms, wellbeing and dignity need to be considered when discussing tilapias viability as an adaptation solution particularly in PICTs where tilapia is not a mainstream indigenous commodity.

Figure 2.5 Nile tilapia in captivity

Source: (Roughfish.com, 2021)

Another growing aquaculture sector in the Pacific region is limu (seaweed or sea grapes). A variety of limu species are farmed and consumed but sea grapes (*Caulerpa racemose*) are the species promoted in the Samoa 2021 limu revitalisation project. Limu are a traditional food source found in shallow areas across the Pacific. Limu is highly nutritious and contains several minerals, vitamins, and proteins (see figure 2.6) (Lesa, 2021). Limu is consumed across the Pacific and is particularly common in Hawaii where it is eaten as an integral feature of the traditional diet (Lesa, 2021). In recent years, limu has been touted as a healthy and alternative 'super food' that can contribute to healthier diets for Pacific islanders who in certain states suffer from abnormally high rates of obesity (Lesa, 2021). Limu is particularly high in minerals such as magnesium and calcium, and just 10 grams of limu powder can provide up 60% and 43% (respectively) of the recommended daily allowance for the above-mentioned minerals. Limu is also rich in folic acid and is used medicinally in Asia as a treatment for high blood pressure (Fithriani, 2015). Importantly, limu has been put forward by the UNDP and others as a climate change adaptative mechanism as the cultivating of limu will allow for a continuous supply of food in the face of climate change impacts (Lesa, 2021). On a smaller scale, limu can be harvested through traditional methods and provide food and incomes for people of the indigenous fishing industry.

Food type	Protein content per 100 grams
Sea grapes/Limu (*Caulerpa racemose)*	19%
Chicken Breast	31%
Yellow fin tuna	25%

Figure 2.6 Comparisons of protein content between Limu and foods typically associated with high protein content.

Source: (www.healthline.com, 2021)

The production of limu is becoming widespread throughout the Pacific region and, as of the past three years, has reached Samoa where it has been trialed as a food source that can double as an adaptive mechanism for climate change. Similar to tilapia, the viability of limu as an adaptation strategy remains to be seen. Although limu has numerous promising features, to be a viable climate change adaptation measure, limu needs to be accepted and consumed at a rate that can significantly supplement and replace depleting sources of marine protein as well as remain accessible to indigenous fishers. As part of this research, discussions with key stakeholders within aquaculture and limu production (see chapter 5.5) have revealed limu's future role as an adaptation solution.

2.9 Chapter Summary

Fisheries across the Pacific region are in a precarious state. The onset of climate change paired with the overexploitation of marine resources are threatening the survival of coastal marine environments and the creatures that inhabit them. Hundreds of thousands of people across the Pacific rely on the ocean as a means of food security and prosperity. With limited natural resources in comparison to larger regions, people of PICTs consume and harvest marine resources on a significantly higher scale, particularly in the coastal subsistence sector. To ensure the survival of these coastal marine environments, development that values the voices of indigenous peoples is needed and is essential when formulating adaptation frameworks for the indigenous fishers among PICTs. The following chapter will focus on the Samoan coastal

fisheries sector and will give an overview of the sector, the impact of climate change on coastal fisheries and provide an example of a national adaptation framework for fisheries. The chapter will also discuss Samoan aquaculture and its current role in coastal fisheries.

Chapter 3: Samoa and the indigenous fishing industry

3.1 Introduction

This chapter will introduce Samoa's indigenous fishing industry and discuss the context behind the effort to introduce climate change adaption strategies. Samoans have a connection to ocean that has spanned millennia. Understanding this connection is important to grasp the magnitude of the problems now facing Samoa's indigenous fishing industry. This chapter will discuss first this cultural and spiritual connection, before providing an an overview of Samoa's indigenous fishing industry and the current/future impacts of climate change and environmental degradation on the industry.

This chapter will then provide context on the focus of this thesis, climate change adaption strategies and aquaculture in Samoa. An overview of one of the key strategic frameworks that is currently delivering adaptation solutions will be discussed as well as a brief history of aquaculture in Samoa. A discussion on the effort to re-establish and implement the practise of limu farming will conclude this chapter.

3.2 Cultural Significance of Samoa's oceans

Samoa lies within the heart of Polynesia in the Southern Pacific Ocean. Also known as the cradle of Polynesia, the island of Savai'i (Samoa's second largest island) is said to be Hawaiki, the Polynesian homeland (Foster, 2024). Samoa's ancestors were master navigators or way finders who settled the islands over 2,000 years ago. Samoans navigated the vast Pacific on the double hulled Va'a (canoe) exploring the expansive waters and distant lands of the Cook Islands, Tahiti and Rapa Nui (Easter Island) using the stars and the winds, knowledge collected over centuries (Dijken, 2020). For Samoans and Pacific islanders, the Pacific Ocean has served to unite the sea of islands as a 'blue highway' and remains at the centre of life and culture (Dijken, 2020). Samoans have a deep connection to the sea and this bond formed through

respect and reliance on the ocean, has endured and is rooted in the identity of all Samoans (Govt. of Samoa, 2020).

The Pacific Ocean plays an important role in Samoan folklore and features in numerous legends and myths. The Samoan legend of the turtle and the shark tells the story of a mother and daughter who turned to the sea in a time of famine and were transformed into a turtle and a shark. The women were welcomed by the chief of Vaitogi and would reside beyond the cliffs of the village. These same cliffs see Samoans gather and to sing and catch a glimpse of the shark and the turtle *(The tale of the turtle and the shark – a Samoan legend)*. In another tale, the story of Sina and Tuna, an eel (Tuna) yearns for Sina with an unrequited love to no avail and wills himself to death. This tale is said to be the origin of the coconut tree an essential aspect of Samoan agriculture (Ta'isi Efi, 2008).

According to indigenous Samoan knowledge, each living thing shares a common origin; water is connected to land which is connected to humans which is connected to the cosmos and gods. This connection invests a responsibility on all living things to provide reciprocity and maintain harmony. This sacred balance is called Va Tapuia (sacred relations) (Ta'isi Efi, 2008). For Samoans, the sacred balance means water has life and holds mana and power. Water and the sea are an integral part of life rooted into the identity of all Samoans. The legends of the turtle and the shark, Sina and Tuna and many more symbolise the commitment of Samoa's indigenous community to the sacredness of life. They explain Samoa's culture of conservation and respect for water, the life-giver (Ta'isi Efi, 2008).

Within cosmology, spiritualty, and society, water and the ocean are critical to the lives of Samoans. With ocean compromising of 98% of Samoa's territory, Samoa is a large ocean state with the sea at its epicentre as the primary resource for food and livelihoods' (Ta'isi Efi, 2008). This precious resource needs the culture of conservation held within indigenous Samoan knowledge to ensure its health and longevity both as a resource and life-giver.

3.3 Background on Samoa's fishing industry

Samoa is a collection of small volcanic islands located in the Southern Pacific Ocean bordered by Tonga to the south, Tokelau to the north and is approximately 2,900km northeast of New Zealand. Samoa's climate is tropical and humid boasting lush inland rainforests, expansive mangrove swamps and vibrant fringing reefs (Foster, 2024). Samoa's limited land size (2,935 km2, which is roughly the size of US state Rhode Island) is made up for by the extent of its oceanic realm. Samoa's surrounding seas make up 98% of Samoa's total area and includes an Exclusive Economic Zone (EEZ) of 129,000 km2. Despite being 44 times larger than its landmass, Samoa's EEZ is dwarfed by its neighbours. Tonga, American Samoa, and nearby Kiribati hold and EEZ of 700,000 km2, 400,000 km2 and 3,550,000 km2 respectively (Nataro, 2024). This can be attributed to a geographic peculiarity; Samoa is 'sea-locked' (See figure 3.1). Samoa's proximity to surrounding island nations prevents its EEZ from extending the full 200 miles from land (which is the international standard) creating a geographic disadvantage. A drastically reduced EEZ severely hinders Samoa's ability to source fish and other marine resources. However, Samoa does have an advantage relative to its neighbours with bottom depth, as its ocean contains vast sections of deep sea which supports substantial fish populations (Nataro, 2024).

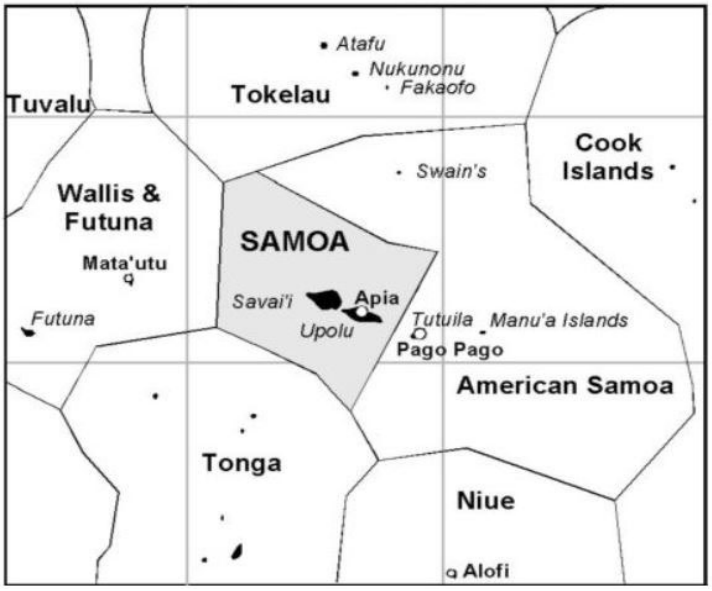

Figure 3.1 Samoa's 'sea locked' EEZ *Source: (Nataro, 2019)*

Traditionally, fishing in Samoa would involve techniques such as throwing a net (kili), sling spearfishing (tuli a'au) and casting (fai'ofe) all of which can be done from outrigger canoes (paopao) (see figure 3.2). There are instances of communal fishing (lau) where fish such as a big-eyed scad (atule) are driven toward the shore with coconut leaves for harvesting. In parts of Samoa, shark fishing using rope lassos (tui-ipu) and shark clubs (paletua) are still practised particularly in areas with poor fish populations (see figure 3.3) (Tuioti, 1955). These forms of fishing were and are currently practised in and around coastal areas, lagoons, and reefs. Although these forms of fishing can take place several miles offshore, it wasn't until the 1970s that Samoa began to fish in deeper waters using alias.

Alias as a fishing craft, are unique to Samoa and can be described as a catamaran stye vessel approximately 9 meters in length, typically powered by 40 horsepower outboard motors (see figure 3.4). After small scale pole and line operations failed to become profitable, these vessels became the predominant vehicle of commercial fishing in Samoa and would peak in use with a fleet of 200 ships in 1999. However, due to overfishing, natural disasters, safety issues and Samoa's limited EEZ, the use of alias declined significantly over the next 4 years (Food & Agriculture Organization, FAO, 2018). As of 2018, commercial fishing is conducted almost exclusively through the use 21 longliners and 53 bottom trawlers made up of remaining alias and larger monohull vessels (Food & Agriculture Organization, FAO, 2018). These vessels supply the vast majority of Samoa's fish exports.

Figure 3.2 A traditional paopao (canoe) stashed alongside the north-western road of Upolu (photo: author)

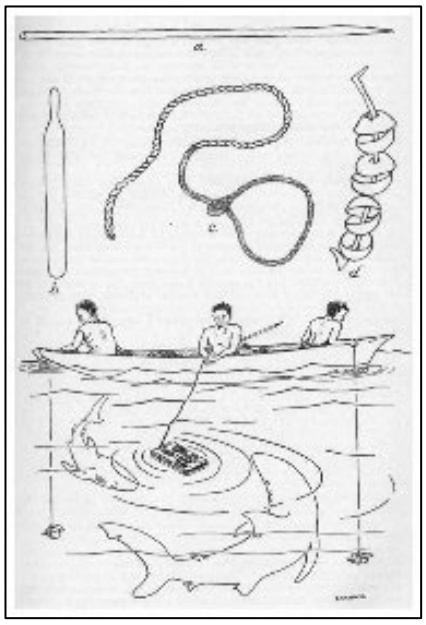

Figure 3.3 – Equipment and technique for Shark fishing

Source: (Tuioti, 1955)

Figure 3.4 Alia docked at the Apia fish market (photo: author)

The commercial fishing industry holds great economic value for Samoa. In 2020, fish exports were Samoa's top export commodity bringing in 43.6 million Western Samoan Tala (WST), (26 million NZD) per annum, accounting for 30% of the export market and 2% of total GDP (Fruen, 2021). In 2015, total fish production was estimated at 8700 tonnes with 13 tonnes stemming from aquaculture (see figure 3.5). Per capita, consumption of finfish amounts to 48.5kg/year (18th highest in the World) and 24% of animal protein consumption. Most commercial catches consist of pelagic fish, namely tuna such as albacore and long-fin which are a staple across much of the Pacific (Food & Agriculture Organization, FAO, 2018). Albacores make up 70% of the catch followed by yellow-fin (11%) skipjack (3%) and big eye (3%) the remaining catch consists of marlin and other large pelagic species (Food & Agriculture Organization, FAO, 2018). Although Samoa's EEZ contains a high density of fish species (and without factoring the potential impact of climate change), tuna populations are in

a precarious position and will likely decline if catch sizes increase. In an almost extreme contrast, the indigenous fishing industry source over 500 species of fish/marine species (see figures 3.6, 3.7) (Food & Agriculture Organization, FAO, 2018).

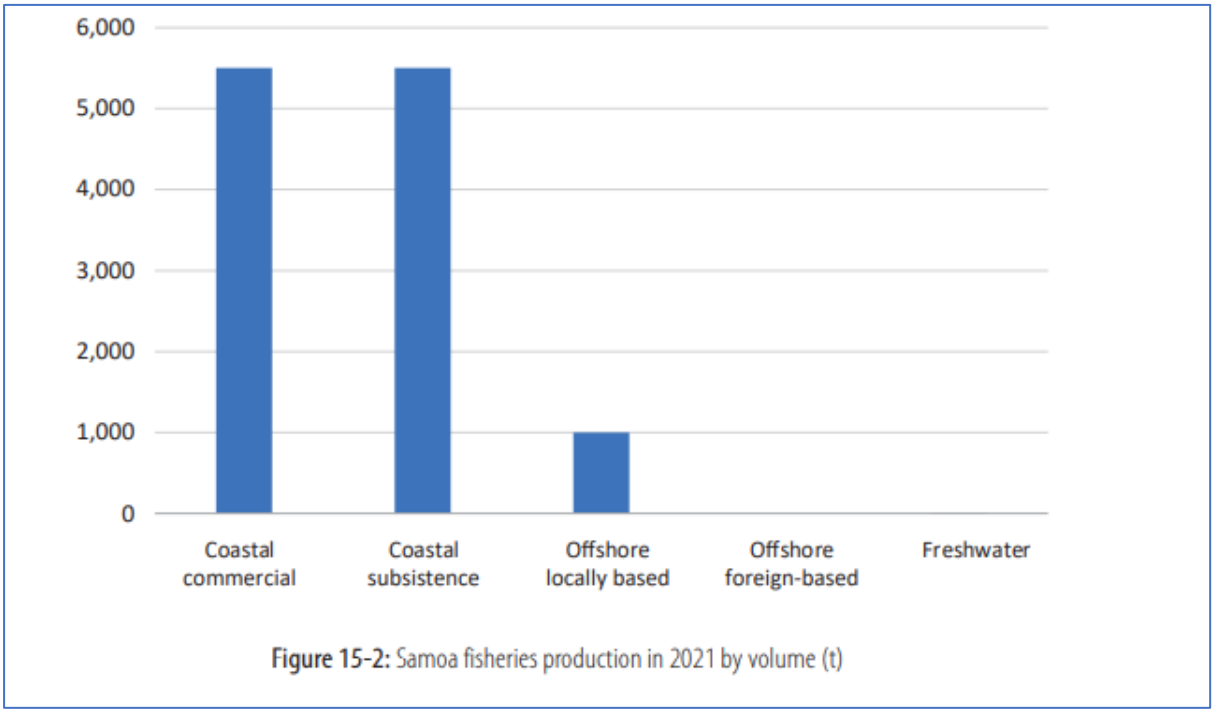

Figure 3.5 Samoa's fishing industry by production

Source: (Gillett & Fong, 2023)

Differences in catches between inshore fishing and deep-sea fishing

Figure 3.6 Diverse catch at the Apia fish market.
caught freediving. (photo: author)

Figure 3.7 Catch at the fish market caught on alia.
Various pelagic species can be seen. (photo: author)

3.4 The indigenous industry

Samoa's indigenous fishing industry consists of people who partake in fishing in coastal areas for daily sustenance, subsistence, and wellbeing (Food & Agriculture Organization, FAO, 2018). In 2014, fishing employed 14% (this recording is low when comparing to 1999 levels likely due to the 2009 tsunami) of all households and as many as 10,000 (of Samoa's 220,000) people were directly engaged in subsistence fisheries (Food & Agriculture Organization, FAO, 2018). Similar to the majority of PICTS, the indigenous fishing industry produces more economic income than commercial fishing and involves far more people. These people harvest over 500 species ranging from grouper to octopus and giant clams. Most fishing is done along coastlines and lagoons meaning that most of the catch consists of coastal fish (demersal and near-shore pelagic fish) rather than the commercial, deep water pelagic species. The vast majority of fish caught in the indigenous fishing community/industry are caught for household consumption. Of the roughly 5000 households actively engaged in fishing, only 2.5% consistently engage in the selling of fish and this is typically due to surplus catches (Food & Agriculture Organization, FAO, 2018). This low level of external trade is an important testament to the role the ocean and its resources hold in the lives of Samoans and the significance of Samoa's indigenous fishing industry.

The consumption of fish is highly important for Samoans. Accounting for 24% of all animal protein, in 2012 Samoans consumed per year on average 48.5kg of finfish, 54kg of invertebrate species and 28kg of canned fish (Food & Agriculture Organization, FAO, 2018). Finfish are consumed (on average) 2.7 times a week and invertebrates 1.3 days per week (Tiitii et al., 2014). In coastal communities one in four households own a boat and fishers in these households can make up to 196 fishing trips per year (Tiitii et al., 2014). In 2021, the value of the total estimated catch of all marine species was 103 million WST (62 million NZD), hugely significant considering that, in 2013, Samoa's entire GDP was 1,429 million WST (862 million NZD) (Tiitii et al., 2014). Aside from household consumption, fish and marine species are often used for faasoso, the gifting of fish to others. A survey of 1000 households found that fisherman will consume two thirds of their catch and give away the remaining third (Tiitii et al., 2014).

An interesting case study of faasoso can be seen when returning to the lau, the harvesting of atule. In Samoa, villages such as Ofu of Manu'a and Fagasa and Leone of Tutuila continue to capture atule using lau, the driving of bigeye scad toward the shore with coconut leaves through a communal effort. Once the atule is captured, the catch is distributed equally between participating families. If the catch is large, atule is distributed among friends and family in nearby villages. Atule are considered a gift from god and the gifting of fish are part of the reciprocal relations of Samoan society (Tiitii et al., 2014). These traditions uphold social structure and maintain va tapuia (sacred relations) signifying the importance of the indigenous fishing industry.

3.4 The impact of climate change and environmental degradation on Samoan fisheries

For Samoa, warming waters will cause a range of environmental, social, and economic issues from increasingly severe cyclones and extreme weather patterns to the proliferation of water-borne disease. In the immediate-term, costal erosion and coral bleaching have been identified as the two main climate change related threats for Samoa's ocean environments. These threats already have begun to deal extensive damage to Samoa's coastlines.

Coral bleaching is the disruption of the symbiosis between coral and its endosymbiotic algae (Ziegler, 2019). When algae die-off due abnormally high-water temperature, the coral tissue will turn white. Coral can survive bleaching but if a bleaching event occurs frequently and for long enough, vast swathes of reefs can die which eliminates fish and invertebrate habitats leading to ecological dead zones (Ziegler, 2019). During the 2015/2016 El Niño event, the earth experienced the 'third global coral bleaching event' (Hess, 2024). This event caused much of the widely publicized devastation of Australia's Great Barrier reef but would also go onto seriously impact Samoa's reef systems (Hess, 2024). A fourth global coral bleaching event is projected to begin in 2024 triggered by a heavy El Niño and is predicted to be the worst bleaching event in history (Hess, 2024). All reefs across the entire southern hemisphere are expected to bleach which will no doubt have a devastating impact on coastal fish species and the people that rely on those species for survival (Hess, 2024).

Unsurprisingly, climate change poses a significant risk to Samoa's indigenous fishing industry. Compounding the main threats of coral bleaching and coastal erosion are plethora of climate

change related environmental issues. Samoa will likely suffer the same impacts as most PICTs (see section 2.5) in the coming years as result of climate change. Water temperatures of the Pacific are to increase substantially by the end of the century. Increased solar radiation (particularly in shallow areas subject to rapid warming and cooling) will push marine species out of their optimal temperature zones. Not only will these temperatures be deadly, but they may also alter metabolic and reproductive patterns, preventing species from recovering in times of stable conditions. Warmer temperatures also will generate knock on effects such as the altering of ocean currents. Changes in currents can hinder the distribution of nutrients and fish larvae, rendering biological production patterns redundant (Bell et al., 2011).

In addition to rising sea temperatures, Samoa's waters will suffer from ocean acidification. Climate change is currently increasing the concentration of hydrogen ions in the water which is reducing the pH of the Pacific by 00.2 units per decade. Under both low and high emissions modelling, the rapid increase in hydrogen over the next few decades will lead to the fastest reduction in pH for 300 million years (Bell et al., 2011). Thousands of marine species will suffer from this rapid change as mentioned in section 2.5 (Bell et al., 2011).

These impacts will initially generate a moderate risk for Samoa's fish populations but, in the second half of the century, these impacts will put Samoa's marine species under high-risk vulnerability meaning the catches will not be able to sustain minimal levels needed to maintain marine consumption levels (Bell et al., 2001).

Similar to other PICTs, these huge changes will have profound impact on the on-going significance of TK systems. Irregular weather patterns and the altering of ecological systems may soon render TK, and TK techniques, redundant as patterns recognised and recorded over centuries become less relevant.

Aggravating the impacts of climate change on Samoa's indigenous fishing industry are numerous sources of environmental degradation. In recent years, the invasive, coral eating alamea (crown of thorns) has devasted costal reefs. Outbreaks of alamea can rapidly decimate reef-systems and in 2011, an alamea outbreak in the Taema bank area in American Samoa left the reef unrecoverable (Tiitii et al., 2014).

Arguably the biggest non-climate change related threat facing Samoa's indigenous fishing industry is over-fishing and a lack of suitable development in coastal areas. Unsustainable development of coastal areas includes the clearing of mangrove swamps, sand mining and

degradation, and land-based pollution. Lack of regulation around fishing has also led to overfishing through illegal, unsustainable, and over extractive fishing activities (Govt. of Samoa, 2020). Extensive damage to reefs and coastal environments have pushed coastal marine species in Samoa to an extremely vulnerable position and is threatening the livelihoods of thousands of indigenous fishers who rely upon these species. Critically, actions geared toward mitigating and adapting to these impacts and the impacts of climate change are well underway at a local, national, and regional level through a number of institutions and strategic frameworks, as discussed below.

3.5 Existing climate change adaptation frameworks for Samoa's fishing industry

Several international, regional, and local frameworks have been developed to address the impact of climate change on Samon fisheries. This research will primarily focus on polices implemented at the national level and looks to discern whether national adaptation polices adequately address the needs of those involved in Samoa's indigenous fishing industry who often bear the brunt of climate change and other impacts. While interviewing stakeholders on the subject, the key adaptation framework example used was the Samoa Ocean Strategy 2020-2030.

The Samoan Ocean Strategy (SOS) was devised by the Samoan Government in conjunction with Conservation International, and is a comprehensive assessment of Samoa's fisheries sector. The plan takes a holistic approach and looks to promote the conservation of Samoa's seas for the benefit of all relevant stakeholders (Govt. of Samoa, 2020). The plan outlines the threats faced by the fisheries sector (climate change being the most pertinent threat) and recommends adaptation in six thematic areas including the formation of a National Ocean Steering Committee to consolidate Samoa's maritime borders and EEZ.

The SOS looks to protect Samoa's coastal environments, the source of over half of all Samoa's marine resources. Samoa's limited number of coral reefs paired with extensive damage from cyclones and the 2009 tsunami, means that measures are required to ensure the future safety of these environments. The plan outlines policies to mitigate and adapt to the impacts of climate change on coastal marine environments and through avenues such as environmental protection bills. Awareness building through shows and workshops across Samoa is also suggested in the plan to promote effective costal management. This awareness building also looks to increase

the public's knowledge of climate change and invoke action form the ground up (Govt. of Samoa, 2020).

The SOS recognises the role of the ocean in food security. According to the SOS, 90% of locally sourced protein consumed in Samoa comes from the ocean (Govt. of Samoa, 2020). Consequently, food security in Samoa will be largely dependent on the sustainable management of marine resources. Among other policies, the SOS recommends sustainable aquaculture ventures to improve food security and provide alternative incomes for villagers (Govt. of Samoa, 2020).

The SOS is clear in its direction which aims to implement adaptation solutions that work form the ground up and in a sustainable manner. Now that the SOS has been put into action, the extent to which the polices and recommendations of the SOS are being received and whether the polices recommended by the SOS were wanted, will be discussed in chapter five.

3.6 Aquaculture in Samoa

Across multiple adaptation frameworks for Samoan fisheries, aquaculture is consistently cited as an effective adaptation solution. As mentioned, Samoa has a small and highly limited aquaculture sector primarily based around the culturing of Nile tilapia but, there is currently no aquaculture production at a commercial level. A 2019 agriculture census found that 98 households in Samoa actively engaged in aquaculture, 25 of which were cultivating tilapia (Gillett & Fong, 2023). As mentioned in section 2.8, tilapia is a hardy and resilient freshwater fish species able to withstand extreme and adverse weather conditions while growing to significant sizes within months. Tilapia has been farmed in Samoa since the 1970s but has seen a resurgence with the introduction of the Nile tilapia, a less aggressive, larger, and faster growing sub-species (Su'a et al., year not specified). Tilapia can be farmed in earth and cement ponds and is farmed in 51 locations across multiple Samoan islands (see figure 3.8). Although tilapia is widely accepted across the world as a food fish, the consumption of tilapia in Samoa is extremely limited when compared to coastal fish species (Su'a et al., year not specified). However, due to their easy to farm and resilient nature, and ability to farmed at a local level, tilapia is an obvious candidate for climate adaptative aquaculture production.

Figure 3.8 Lake Satoalepai, a lake in Northern Savaii stocked with Nile Tilapia

Source*:* (Su'a et al., year not specified)

Limu is an emerging form of aquaculture in Samoa that has been regarded as a potential food source to improve food security in the face of climate change. Limu has been a part of the Samoan diet for centuries and holds important cultural significance, often gifted on special occasions (see figure 3.9) (Swanepoel, 2023). However, limu is seldom eaten on a consistent basis and is considered underutilised particularly as an indigenous food source. As discussed in section 2.8, limu is highly nutritious and can provide significant levels of protein which can at help to supplement the traditionally protein and marine heavy diet of Samoans. Limu is grown in shallow, coastal areas and can be harvested using indigenous techniques while minimising the impact of the surrounding environment.

A high abundance of limu combined with a resilience toward climate change and a plentiful source of nutrients make limu an important candidate for climate adaptative aquaculture (Swanepoel, 2023). This potential has been recognised by Samoa's Ministry of Agriculture and Fisheries (MAF) which has implemented a limu revitalisation project to kickstart the cultivation of limu across Samoa. This project, which will be discussed in chapter five, can provide indigenous fishers with a new and steady supply of marine food with the potential to supplement and replace depleting sources of coastal species. However, the true viability of limu as an adaptation solution for the indigenous fishing industry is hindered by several factors which will be covered in chapters five and six.

The culturing of giant clams is another noteworthy Samoan aquaculture venture which doubles as a sustainable tourism site and an occasional food source. The fisheries division of MAF spawns 10,000 clams annually which are sold for consumption and the giant clam site at Savaia village is a popular destination for tourists that provides income for the village (Gillett & Fong, 2023).

Figure 3.9 Man selling Limu at Lyn's supermarket, Apia. (photo: author)

3.7 Chapter summary

Samoa's surrounding oceans and marine resources hold a central place in the history, culture, society, and wellbeing of Samoans. Samoa's unique fisheries sector and its immensely important indigenous fishing industry are crucial to the everyday lives of Samoans who rely upon its resources for their wellbeing. With incredibly high levels of seafood consumption and deep cultural, society and spiritual ties to the ocean, the maintenance of these crucial resources an environment is now more important than ever as the impact of climate change and environmental degradation begin to take their toll on Samoa's marine ecosystems.

Fortunately, a significant amount of work has been planned and implemented through the likes of the SOS 2020-2030 to properly govern and protect Samoa's ocean resources. The importance of aquaculture, one of the recommendations of the SOS among other frameworks, has sparked an effort to grow the fledgling industry to relieve the pressure on coastal resources and provide sustenance as well as income for coastal communities. However, the actual viability of aquaculture as an adaptative solution particularly for the indigenous fishing industry needs to be properly scrutinized, and hence is the focus of this research.

Chapter Four: Methodology

4.1 Introduction

This chapter will introduce my chosen methodology for this research. My fieldwork consisted of a qualitative study that took place over three weeks in Samoa. This chapter will introduce the qualitative research methods employed during my fieldwork and will outline the Pacific research principles which I adhered as I conducted my research. This chapter will then discuss my positionality as a western, Pakeha male conducting research within a field involving indigenous peoples and indigenous knowledge and explain how I respected the culture and customs of the people involved in my research. This chapter will finish by outlining fieldwork limitations that were encountered while conducting my research in Samoa.

4.2 Qualitative research

My research employed a qualitative methodology for the purpose of generating "*thick, rich description*" (Stewart-Withers et al., 2014, p.61). This form of research can help us to understand, extrapolate and find meaning (Stewart-Withers et al., 2014). This methodology enables the researcher to explore people's attitudes, interpretations, behaviours, value systems, concerns, motivations and aspirations (O'Leary, 2017). Qualitative research is best suited to my research topic as the research itself will need to be flexible in nature, will focus on a particular group, and look to find interpretive data (Scheyvens et al., 2014). Speaking with participants and experts in their given fields as noted by (Creswell, 1998: 18) will required me to be an active learner and present the story from the participants view rather than my own (Scheyvens et al., 2014).

4.3 Pacific research principles

When conducting research in the Pacific it is important that researchers follow Pacific research principles while also recognising the existence of distinct and individual protocols and customs in each Pacific Island country (PRPC, 2017, p.17). These Pacific research principles include respect for relationships, respect for knowledge holders, reciprocity, holism and using research to do good.

Embedding holism into my research was particularly important as the Samoan indigenous fishing industry is intertwined with Samoan spirituality culture and society. I maintained awareness of the interconnected nature of Samoa's physical coastal marine environments and well as cultural, spiritual and social practices.

When conducting research, it is important to consider what you can give back to those who have given up your time and provided you with assistance (Scheyvens, 2014). Reciprocity or gift giving is an important part of Pasifika culture and research. According to Massey University's Pacific Research Guidelines, reciprocity is not only monetary but can also be time and service (PRPC, 2017, p.17). To ensure that I acknowledge the assistance and valuable information provided to me by my participants, I will aim to return research data to any interested participants.

While in Samoa, I presented my preliminary findings to participants following the conclusion of my research to show my appreciation of their time and assistance. I was also be transparent about the use of my research and ensured that permission from participants was granted through my information sheet and consent form.

4.3 Qualitative research methods

My research consisted of three weeks of in-country fieldwork in October 2023. My main methods of data collection was via:

1) semi-structured/structured interviews with key informants who will be members of local and regional institutions and Samoan Govt. officials (e.g., South Pacific Regional Environment

Programme (SPREP), the Samoan Ministry for the Environment (MNRE) and the Samoan Ministry of Agriculture and Fisheries (MAF);

2) document analysis of key national and regional adaptation frameworks for Samoan fisheries.

3) observation of the Samoan indigenous fisheries sector

4) informal conversations but still with direction, with members of the indigenous fishing community

5) keeping of a fieldwork diary.

In terms of participant numbers, I originally aimed for 2-3 coastal communities, with 2-3 participants in each community and then Samoan Government officials with the idea of interviewing 4-5 participants in total. Informal conversations with coastal community members and anyone with knowledge of Samoan fisheries was conducted as frequently as possible and on an ad hoc basis.

Regarding participant recruitment, I started by interviewing existing contacts at the Samoan Ministry for the Environment and SPREP and then used the snowball technique to gain further contacts to interview. I used open/informal conversations to gather data within local villages if and where appropriate.

Alongside the interviews, I will used a fieldwork diary. My diary was a day-to-day record of events and observations while conducting my research. The diary was used to record practical decisions throughout the research process and kept track of any conversations had, locations visited, and any small insights that I observed. The diary also served as a logging device and I recorded details and observations that can be referred to for my thesis.

Data was analysed thematically. In qualitative research, the researcher generally moves backward and forward between collection and analysis (O'Leary, 2017). Qualitative thematic analysis involves making sense out of all the information by consolidating, reducing, and interpreting what people have said and what the researcher has seen and read—it is the process of making meaning (O'Leary, 2017). The intention is to identify themes and patterns and develop a framework for understanding and communicating what the data has revealed (Stewart-Withers et al., 2014). Once analysed, the data will be presented in a narrative style and will be divided between each research question and sub question.

4.4 Positionality

Conducting research in a different country with its own culture and social customs requires that I address my positionality. As a western researcher and white Pakeha male, it is critical that I reflect on the impact that I could have on the research environment, particularly when researching indigenous communities and practices.

When conducting research, I had to bear in mind that historical experiences of imperialism and colonialism have caused many indigenous groups to remain cautious of foreign researchers (Scheyvens et al., 2014). This is particularly relevant given New Zealand's historical, colonial relationship with Samoa (Scheyvens et al., 2014). It is also important to acknowledge that western researchers are often preoccupied with their own agendas (Scheyvens et al., 2014). To mitigate these exploitative research practices and to ensure that indigenous knowledge and Samoan cultural practices are respected, I sought to embed the Massey University Pacific research guidelines into all aspects of my research (see 4.2).

As a male researcher, I also had to make a conscious effort, if appropriate, to reach out to women as participants in my research. In the Samoan indigenous fishing community, women are vital to the process of harvesting and preparing fish for consumption and for income (Toeolesulusulu Cedric Schuster, 10 October 2023). Taking an inclusive approach that seeks the voices of all genders is important to ensure that my research adequately addresses the reality of indigenous fishing in Samoa.

While I may appear to be your average young Pakeha male, I was privileged to have spent a number of years of my childhood in the Pacific. The three years that I lived in Samoa (including during the tragic Samoan tsunami of 2009) and the six years in Fiji, have given me a deep connection to the Pacific. This connection is what has motivated me to conduct research within Samoa and reconnect with Samoa's land and people. Spending a prolonged period in the Pacific has also given me connections to key leaders in Samoa which enabled me to gain insights that would not normally be available to someone in my position.

In-country, I ensured that I was respectful of cultural norms and maintained respect for Samoan culture. This included translated consent and information forms, wearing a traditional lavalava when necessary and showing reciprocity through gift giving as well as the returning of data to

research participants in accordance with Pacific research principles service (PRPC, 2017, p.17).

4.5 Fieldwork in practice

Prior to traveling to Samoa, the intention was to interview 3-4 members of local institutions regional development organisations and NGO's as well as 2-3 local members of the indigenous fishing community. However, upon arrival, I quickly realised that I would need to reassess and prioritise interviews with 4 key stakeholders in Samon fisheries and climate change adaptation sectors.

The first interview was with a highly valuable, existing connection with Hon. Toeolesulusulu Cedric Pose Salesa Schuster, the Minster of Natural Resources and the Environment (MNRE). Having known the Minister and his family for many years, I was privileged to have had the opportunity to stay with him and his family for the first two weeks of my fieldwork. Through another connection with the Director General of SPREP, Sefanaia Nawadra, I was able to use the SPREP offices in Apia as an office space and a means to conduct interviews with two members of the Islands and Eco-systems program. The second interview was with Unity Roebeck, a conservation consultant for SPREP with a background in aquaculture who would also assist me in gaining an interview with Ulusapeti Tiitii, the Chief Principal Fisheries officer for inshore fish and aquaculture at the Samoan Ministry of Agriculture and Fisheries (MAF). The fourth and final interview was with Nicolas Rocle, a coastal marine specialist working at SPREP on secondment from the French Government. Nicolas specialises in ecosystem-based adaptation (EBA's) and nature-based solutions (NBS) for climate change.

All of the participants were interviewed with the same set of questions, but some questions were altered depending on each participant's speciality. These sets of questions have allowed me to develop common themes that will be outlined throughout this chapter.

In addition to the 4 interviews, fieldwork included informal conversations with coastal community members when possible. This included fish sellers on roads around Upolu, family members of interviewed participants and members of the Apia Anglican community. Because of language barriers, these conversations were kept short and were largely focused on limu as

a form of aquaculture. These conversations helped to gauge a consensus on the local delicacy and would corroborate findings from the 4 key interviews.

The final aspect of the research was observation. Over the three weeks on Upolu, fieldwork would include travelling to various sites including the Apia fish market, Savaia giant clam sanctuary, and the entire coastline of the main island. Frequent trips were made along the north-western Road of Upolu, the main hub for roadside fish sellers. These sites provided contextual information and helped paint a visual picture of Samoa's indigenous fishing industry.

4.5.1 My positionality in practice

While my background and connections gave me unprecedented access to Samoan leaders and decision makers, it also ironically made it difficult for me to fully implement my research plan. For example, I was not able to access the Toloa hatchery where tilapia and limu were being grown as I was specifically instructed by the Chief Principal Fisheries officer of the Ministry of Agriculture and Fisheries (one of my key research participants) not to do so. She explained that the site would not be ready for a visit and that local fishers and farmers would be reluctant to speak to foreigners. Out of respect for these wishes and in accordance with Massey's Pacific research guidelines, I chose instead to take opportunities to talk to indigenous fishers where possible at fish markets in and around Apia.

Because my presence as a researcher in Samoa was more visible, I had to adhere to strict protocols whereby any request to speak with members of government had to approved at the highest level. This process was time consuming and ultimately restricted the number of semi-structured interviews I was able to undertake.

In addition, I was unable to have conversations with local fishers as was intended prior to travelling to Samoa. I attempted to approach roadside fish sellers but due to language barriers and a reluctance to communicate I was unable to gain any data directly from Samoa's indigenous fishing community. Gaining access to indigenous voices was important for my research as I would be investigating a field consisting of solely of indigenous fishers. Fortunately, two of the participants that I interviewed had connections to indigenous fishers

through their work in formulating adaptation plans for indigenous fishing communities and could serve as spokespeople for these communities.

Strictly adhering to Samoa's research ethics approval process also proved challenging. I discovered when I arrived in Samoa that the National University of Samoa's (NUS) ethics committee only met three times a year and had not, therefore, reviewed my ethics application which I had sent prior to arriving in Samoa. I was able to establish through my local connections who I should contact at NUS, however, and, after several email exchanges with the NUS Vice-Chancellor, I was able to obtain ethics clearance.

While having to email the NUS Vice-Chancellor about my ethics approval was a challenging experience, I found that by employing the Pacific research principle of humility aided my correspondence with this academic leader and ultimately led to a successful ethics approval and the gaining of a research permit.

4.6 Chapter Summary

To conclude, this chapter discussed my research methodology and outlined the qualitative approach and research methods I employed during my three weeks of fieldwork in Samoa. Chapter four also discussed my positionality and the measures I took to ensure my research aligns with Pacific research principles and protocols. This chapter concluded with a section on my fieldwork in practice and described some of the limitations of my fieldwork research.

The next chapter will discuss the findings of this research and will analyse the data gathered from the four in-depth interviews conducted with leaders and key stakeholders within the fields of climate change and aquaculture.

Chapter Five: Results

5.1 Introduction

This chapter will address research questions one and two from data collected over three weeks of fieldwork in Samoa. This first section of this chapter will cover the field work context. Over the course of three weeks, four interviews were conducted with key stakeholders within the fields of Samoan fisheries, climate change adaptation and aquaculture. While travelling the island of Upolu, informal conservations with coastal community members and observations were also undertaken to gain a broader insight into the Samoan fisheries sector. This chapter will then discuss both research questions and other associated questions by outlining the data collected from the four interviews in a narrative style. This work was conducted through an indigenous development lens and looked to investigate those whose lives were interconnected with the harvesting of marine resources through sustenance wellbeing, culture, and social practices.

5.2 Fieldwork context

Apia, the capital of Samoa, is a town of 35,000 people located in the central north of Samoa's second biggest island, Upolu. Known for its colonial history and as the final resting place of writer Robert Louis Stevenson, the town is a bustling hub of trade, tourism, nature, and people (Foster, 2024). As the only major settlement in Samoa, Apia is home to the government and parliament, intergovernmental organisations including the Food and Agriculture Organisation and the South Pacific Regional Environmental Program, high commissions and embassies. Apia has a local fish market open seven days a week which also neighbours a fish processing plant that prepares fish for export. The market opens early and exhibits a diverse range of catches, caught on larger long-line vessels, smaller catamaran-style alias, traditional canoes and through spearfishing (see figure 3.5, 3.6).

During rush hour, coastal community members can be seen selling their morning catch along the north-western road extending from Apia to the airport (see figure 5.2). Typically, this may be anything caught within the fringing reef but, local delicacies are also on display including

limu, ‘sea’ (sea cucumber insides sold in recycled soft drinks bottles), and on rare occasions, palolo.

Figure 5.2 Fishers selling *anae* (mullet) on the North-Western Road of Upolu (photo: author)

5.3 The connection between national adaption polices for climate change and members of the indigenous fishing community.

National adaptation frameworks such as the Samoa Ocean Strategy (SOS) 2020-2030 are overarching policies that attempt to promote conservation and sustainability of Samoa's oceans and resources through holistic solutions (Govt. of Samoa, 2020). Similar to overarching regional and international polices such as the 2050 strategy for the Blue Pacific Continent, Toeolesulusulu Cedric Schuster explained that,

> *Regional plans set high ambition goals. These goals need to be broad enough to be utilized by multiple nations but also address the needs of people on the ground. Finding a balance is key* (Toeolesulusulu Cedric Schuster, 10 October 2023).

For Samoa, national adaptation frameworks are no different. Nicolas Rocle explained that the frameworks such as the SOS are more like 'roadmaps' than a specific plan, and the priorities of what are most needed on the ground are contained within these roadmaps. These 'roadmaps' are often dictated by international financing mechanisms (Dr. Nicolas Rocle, 17 October 2023). Because the funding, and therefore the priorities are set at an international level, there is a risk of these frameworks becoming disconnected from what is most needed at ground level. However, for Samoa, this hasn't necessarily been the case. Nicolas explains that "*SPREP and crop agencies try to align their policies with the needs of groups in need of these polices*" (Dr. Nicolas Rocle, 17 October 2023).

The SOS for example, had over two years of consultation with local fishers and those who are already suffering the impacts of climate change and environmental degradation. Nicolas explains that typically, due to financial constraints, smaller countries often find it difficult to do in-depth consultation. However, in Samoa, there is dynamic a network between the community and national government which helps to keep polices connected to the ground. The Minister corroborated this statement citing the extensive network between villages, provinces, and government.

Ulusapeti Tiitii, the Chief Principal Fisheries for inshore fishing and aquaculture at MAF believes that there is a good connection between plans such as the SOS and what is needed at the grassroots level. She was heavily involved with the development of the SOS as well as the consultation process. Ulusapeti, is actively involved in community implementation and believes that MAF and the Ministry of Natural resources and Environment (MNRE) have

embedded the needs of indigenous fishers into national policies for the sector (Ulusapeti Tiitii, 19 October 2023).

In sum, when explaining whether the SOS and other national framework adequality address the needs of those most impacted by climate change Toeolesulusulu Cedric Schuster stated, *"Yes but it's complicated, it's important to have a folding-up process that transfers the need of those most impacted up the chain to higher levels of governance"* (Toeolesulusulu Cedric Schuster, 10 October 2023).

5.4 The importance of Traditional Knowledge in climate change adaption for Samoa's indigenous fishing industry

To ensure the inclusion of an indigenous development perspective, all four participants were asked *How important is it to incorporate traditional knowledge (TK) into adaptation strategies/solutions for Samoa's indigenous fishing industry?* The participants agreed that, where the frameworks (such as SOS) were often lacking, was the inclusion of TK. MNRE Minister Toeolesulusulu Cedric Schuster believes that "*TK should be the base of any framework for management"* (Toeolesulusulu Cedric Schuster, 10 October 2023). In practise, Nicolas Rocle explains that TK is always at the forefront of their work: "*science cannot provide all the answers needed for climate change adaption*" but can be often difficult to implement (Dr. Nicolas Rocle, 17 October 2023). According to Unity Roebeck, historically, fishing in Samoa was for subsistence but now it is primarily for income and as a result, fish stock is decreasing and "*TK is important for managing this depleting resource*" (Unity Roebeck, 12 October 2023). Ulusapeti Tiitii echoes Nicolas's point that the existing science around climate change adaptation cannot paint the full picture of marine environments. TK can tell you what species can be found in a given environment, what species can be seen in each season and what species used to live in a given area (Ulusapeti Tiitii, 19 October 2023). Ulusapeti explains that "*we may have the scientific knowledge but, we have to merge that knowledge with TK to see the full picture*" (Ulusapeti Tiitii, 19 October 2023).

One example of TK in action used by the participants to illustrate the value of TK was palolo (see section 2.3). Palolo is harvested on the 7th day after the full moon (Caspers, 1984). However, coastal communities also consider environmental clues such as the wind-direction, tides and sun which can dictate the exact time to harvest. Through hundreds of years of

observation and the passing of TK between generations, coastal communities can accurately predict the exact time to harvest palolo each year. In some cases, Ulusapeti explains that there can be limited scientific information on fisheries and resources. Consequently, Ulusapeti's work on the 2021 limu revitalisation project required her to gather information from TK sources (Ulusapeti Tiitii, 19 October 2023).

Nicolas Rocle described a recent, SPREP funded project that merges TK with modern, digital technology. Reef Cloud is an online platform that monitors coral reefs and fish data across Samoa (Dr. Nicolas Rocle, 17 October 2023). The platform is currently rolling out in partnership with MNRE. They want to figure out how to include TK from fishers into Reef Cloud because "*local communities know their reefs best and monitor their reefs already*" (Dr. Nicolas Rocle, 17 October 2023). Reef Cloud uses underwater photos and needs communities to participate to add to and consolidate their database. Utilising TK should create a mutually beneficial system and the Reef Cloud team is creating an easy to use, interface to ensure that TK can be integrated into the existing Reef Cloud database (Dr. Nicolas Rocle, 17 October 2023).

Interestingly, although an advocate for TK, Toeolesulusulu Cedric Schuster believes that traditional 'usage' of land is far more important than TK. Traditional usage of land provides context and helps to build an understanding of historical land use. Traditional usage of land applies TK to specific environments and can explain how land can be best utilised or protected. In the minister's village of Satapuala very few villagers now participate in fishing and rely far less on marine resources (Toeolesulusulu Cedric Schuster, 10 October 2023). Directing fishing adaptation efforts to villages such as Satapuala would therefore be counterintuitive.

TK and traditional land usage can direct funding and projects to where it is needed such as women who are still involved in the indigenous fisheries sector and who often require the most assistance. The minister explains that "*we are seeing a nationwide reduction in fishing*" and that "*in many cases, only women are carrying out the traditional methods of harvest*" (Toeolesulusulu Cedric Schuster, 10 October 2023). Clearly, traditional usage provides vital information that needs to be factored into the formulation of climate change adaptation strategies for Samoa's indigenous fisheries sector.

5.5 Aquaculture as an adaption strategy

5.5.1 The 2021 Limu Revitalisation Project

As discussed in chapter two, seaweed is a commonly used food source for aquaculture throughout the Pacific. *Caulerpa racemose* or limu is an abundant species of seaweed found in and around the coastlines of Samoa (Tiitii, 2021). Also known as sea grapes, the small and circular balls of seaweed are sold along the roads of Samoa wrapped in mango leaves and are eaten on special occasions or as a ceremonial condiment but can be used for cosmetics as well (see figure 6.3) (Toeolesulusulu Cedric Schuster, 10 October 2023). Limu is rich in minerals and holds a relatively high protein content of 19% when compared to typical household vegetables. Limu is also widely consumed, a 2022 study on edible seaweed in Samoa found that 95% of non-urban households consume seaweed such as limu on a weekly to monthly basis. Because of this popularity, ease of farming and potential uses as highly marketable 'superfood' limu was targeted as a species for a new development project for coastal communities on Upolu and Savaii (Lesa, 2021).

In the wake of the Covid-19 pandemic and in partnership with JICA and the UNDP, MAF began the 2021 limu project under the Revitalization, Expansion and Diversification of Samoa's Agriculture and Fisheries Sector (REDSAF), and, COVID-19 Preparedness and Recovery: Diversification of the Economic Sector in Samoa (CPRDESS) projects. The project itself, consisted of 10 pilot sites in villages on both Upolu and Savaii. These villages would hold workshops and grow a harvest of limu in their respective shallow coastal areas (Lesa, 2021). The limu would eventually be cultivated by villagers, sold in the market or roadside and any generated income kept within the village.

The project would take a multifaceted approach, to first utilise the adaptative ability of limu as a continuous supply of food that can endure the impacts of climate change. Limu can be constantly harvested and provide a steady supply of calories (Lesa, 2021). However, whether limu can adequately withstand the environmental impacts of climate change is another matter and will be discussed in chapter 6. The second use of the project was to engage villagers in culturing limu to generate income, diversify the supply of food sources and rebuild food security amongst coastal communities in the wake of Covid-19. In addition to these goals, the

project was seen as a pilot for semi-commercial aquaculture techniques that are for and by those involved in the indigenous fishing community (Lesa, 2021).

The project was headed by Ulusapeti Tiitii who holds an extensive background in aquaculture and nearshore fisheries and was an author of a 2022 study on edible seaweeds in Samoa. The project took place throughout 2022 and was deemed a success (Ulusapeti Tiitii, 19 October 2023). Participating villages successfully harvested a crop of limu at the conclusion of the project and in some locations such as the village of Savaia, limu continued to grow naturally and is now actively monitored by MAF.

Ulusapeti explained that after the successful trials, *"we advised the UNDP to build a hatchery to sustain the resource and supply communities with limu*" (Ulusapeti Tiitii, 19 October 2023). The Toloa multispecies hatchery, another initiative under the REDSAF project is currently being constructed to propagate limu and tilapia (Ulusapeti Tiitii, 19 October 2023).

Figure 6.3 Fresh limu bought off a street vendor for 10 WST (approx. 6 NZD) (photo: author)

5.6 Limu as an adaptative mechanism for climate change

Edible seaweed such as limu have been put forward as an adaptative mechanism for climate change. The successful aquaculture trials conducted under the limu project demonstrate limu's capacity for building food-security, generating income for households and as a small-scale export product. However, this project worked as a niche solution for villages that have a favourable environment for culturing limu. Whether limu is a viable adaptation solution across the entirety of Samoa's indigenous fishing community and all those who rely upon that industry is a different question. Participants were asked whether they believed limu was viable adaptation solution that could at least partially replace depleting sources of marine protein.

Ulusapeti Tiitii is adamant that limu will be an important alternative food product to supplement protein and vitamins into the Samoan diet in a future of climate change. Unity Roebeck, to an extent agrees, "*with declining fish populations due to climate change, alternatives such as limu do have potential as an adaptative food source* (Unity Roebeck, 12 October 2023). Although a relatively common feature of the traditional Samoan diet, limu is not considered a staple food (Toeolesulusulu Cedric Schuster, 10 October 2023). Customarily consumed and given as gifts on occasion such as weddings, limu is only eaten as a side condiment and is rarely consumed daily. MAF and Ulusapeti are looking to change this perception and stated that "*we want limu to be a staple food*" and that ideally, "*Samoans look at limu the same way we look at cabbage"* (Ulusapeti Tiitii, 19 October 2023). In addition, barriers such as unavailability, unfamiliarity and taste prevent Samoans from consuming limu regularly (Tiitii, 2021). Age also plays a part in the consumption of limu. Traditionally, limu is consumed by older Samoans with younger Samoans rejecting the food largely due to an overly salty taste (Tiitii, 2021). This trend was corroborated during this research through discussions with coastal community members and members of the Anglican church. From limited discussions, elderly Samoans enjoyed limu on a casual basis often with tuna, pork or other meats (based on fieldwork observations).

As part of the 2022 study on edible seaweeds in Samoa, Ulusapeti found that 95% of participants would consume more limu after hearing of its nutritional benefits and after attending seminars at the National University of Samoa (NUS) (Tiitii, 2021). Ulusapeti

postulates that limu will be widely adopted if awareness was built around its nutritional benefits (Tiitii, 2021). Advocation for limu also ties into current Samoan government food-health campaigns such as 'slash the salt' as limu is inherently salty.

In discussing on the perceived benefits of limu, Unity Roebeck added that limu can serve as an adaptation strategy through its ability to remove excess nitrogen from the water. Large crops of limu can help to filter ocean water and prevent algae blooms which would otherwise have damaging effects on inshore fish populations (Unity Roebeck, 12 October 2023). In order for limu to be consumed widely, the production of limu must be scaled up but also traditional methods of harvest need to be maintained to continue to benefit coastal village communities, Ulusapeti stated that "*the limu project trials were implemented in-part to begin this scaling*" (Ulusapeti Tiitii, 19 October 2023).

Promoting limu as a healthy, alternative food has numerous benefits and will certainly contribute to the well-being of Samoans as well as providing incomes for villages involved in limu harvesting. However, MNRE Minister Toeolesulusulu Cedric Schuster firmly believes that limu cannot be adopted as a staple food and subsequently, cannot sufficiently supplement or partially replace depleting sources of marine protein in a meaningful capacity. According to the Minister, *"limu is an acquired taste, limu is being promoted largely for exporting in a higher value market because limu in Samoa is not popular and cannot be eaten every day, even in the traditional diet*" (Toeolesulusulu Cedric Schuster, 10 October 2023). The MNRE Minister added that limu is normally eaten, at a maximum, up to 3 times a week and is not a needed part of the diet and stated that *"Limu cannot be a staple because it never was"*. Unity Roebeck agreed and stated that Samoans "are *not big on seaweed, limu is more of a condiment/garnish*" and that *"not many Samoans are vegetarians, people would rather buy fish than limu*" (Unity Roebeck, 12 October 2023). Limu does hold value, according to the Minister, is in its export potential. The Minister pointed out that exporting limu, especially to big markets such as Japan and marketing limu to tourists as a traditional food experience "*can create income for Samoans to purchase their actual needed staples*" (Toeolesulusulu Cedric Schuster, 10 October 2023).

5.7 Nile tilapia and other forms of aquaculture

After discussing limu, a recent aquaculture endeavour, participants were questioned on an established aquaculture product, Nile tilapia. As discussed in chapters 2 and 3, tilapia is a small but robust freshwater fish that is farmed throughout the world. Tilapia is seen as an increasingly important source of food and has been put forward as a climate change adaptation solution for food security because of the ease of farming the species and ability to withstand high water temperatures (Maiava, 2019. Importantly, tilapia is an excellent source of protein and can shift pressure away from marine eco-systems to improve inshore fish stock.

The utility of tilapia was first recognised in Samoa in 1955 when it was introduced to provide an alternative supply of fish. Mozambique tilapias were introduced and have since (unintentionally) made their way into Samoa's waterways. Unity Roebeck, an expert on tilapia farming, explained that this species "*was aggressive, competes with endemic species, destroys habitats*" and has a distinct muddy taste (Unity Roebeck, 12 October 2023). In 1991, the MAF fisheries division introduced the Nile tilapia, a genetically improved fish that has superior growth characteristics, is more docile and importantly, heat resistant (Maiava, 2019). According to Unity, with an adequate diet, a Nile tilapia can grow to a plate size fish within six months (the Matalele or Thumbprint emperor fish is a common reef fish of similar size that can take two and a half years to reach plate size) (Maiava, 2019).

Unity Roebeck believes that the farming of tilapia is a viable option for climate change adaptation. The resilient species can provide protein quickly, is resistant to some if the major impacts of climate change such as extreme heat and, with proper management, can be contained within specialised farming ponds eliminating risk of damage to natural eco-systems (Unity Roebeck, 12 October 2023). In addition, a 2018 study on Samoan consumer preferences for Nile tilapia value added products found that 46% of participants agreed that farm-raised Nile tilapia is equal in taste to marine fish (Maiava, 2019). Unity Roebeck also added that one of the biggest factors that inhibits growth in the tilapia markets is reservations around water usage. Typically, tilapia farming requires a significant amount of freshwater of which, Samoa has a limited supply. However, detailed in recycling systems such as figure 6.4, water usage can remain limited and double as an aquaponic farming system (Unity Roebeck, 12 October 2023).

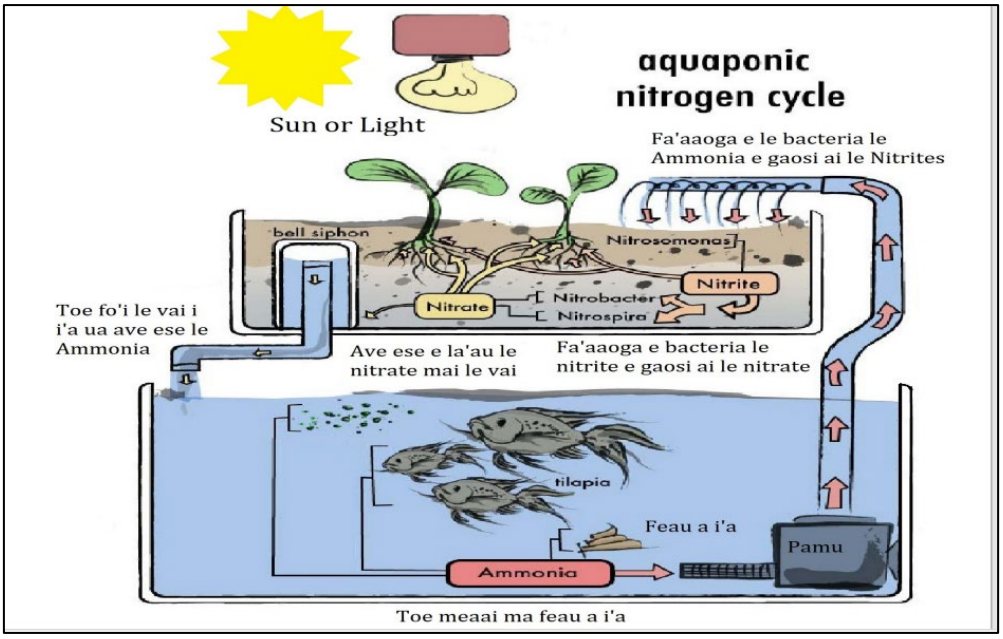

Figure 5.4 A diagram on a tilapia farm that utilises a water recycling system. (Source: SPREP)

MNRE Minster Toeolesulusulu Cedric Schuster disagreed with the idea of tilapia farming as an adaptation solution. In a similar vein to limu, the Minister does not *"want tilapia to be a staple*" (Toeolesulusulu Cedric Schuster, 10 October 2023). According to the Minister, extensive tilapia farming will require a lot of water and that "*small farms that are integrated into wetlands are fine but large-scale farms that require the conversion of wetlands are not sustainable*" (Toeolesulusulu Cedric Schuster, 10 October 2023). There is also an inherent risk of tilapia breaking out of captivity. Should tilapia escape into natural waterways, which was the case with Mozambique tilapia, the species would wreak havoc feeding on almost anything, decimating natural eco-systems (Maiava, 2019). Additionally, the Minister stated that "*Samoans are not used to eating freshwater fish*" and will therefore be slow in adopting a new food source (Toeolesulusulu Cedric Schuster, 10 October 2023). The Minster also pointed out that, "*Nile tilapia have a different taste, they feed on muddy reeds which can lead to a mud-like taste*" (Toeolesulusulu Cedric Schuster, 10 October 2023). This statement raises the idea of whether it is dignified to promote a food source that may have numerous benefits, but is not enjoyed in a cultural, social and literal sense.

5.7.1 Alternative aquaculture solutions

Aside from limu and tilapia, participants were asked if they would advocate for alternative forms of aquaculture as an adaptation solution. Unity Roebeck suggested rock oysters which have begun trials funded by SPC. Rock oysters can filter brackish water and can be resilient to some of the impacts of climate change (Unity Roebeck, 12 October 2023). Unity also added that Asian green mussels have been trialled but that the results were deemed inconclusive (Unity Roebeck, 12 October 2023).

Across the board, the most suggested species was giant clams. As discussed in chapter three, Upolu's south coast is home to a giant clam sanctuary in the village of Savaia. The sanctuary contains hundreds of clams some of which have grown to enormous sizes. The sanctuary's foremost use is as a highly popular tourist destination. However, discussions with coastal community members from Savaia revealed that the villagers occasionally harvest and eat clams that have grown just outside of the sanctuary. The villagers also explained that they may harvest some of the bigger clams in 4-5 years' time. Giant clams are a traditional food source but grow exceptionally slowly with some of the larger clams living over 100 years. Their role as an adaptative food source will likely be jeopardised by this slow growth although Ulusapeti Tiitii pointed out that "*giant clams are an important industry and can tolerate some impacts of climate change*" (Toeolesulusulu Cedric Schuster, 10 October 2023).

5.8 Chapter Summary

To summarise, interviews with key stakeholders within the field of fisheries and climate change adaptation revealed that current national adaptation strategies for Samoa's fisheries and the indigenous fishing industry, for the most part, address the needs of those most impacted by climate change and environmental degradation. The SOS 2020-2030 and similar frameworks underwent an extensive process of consultation over several years and made efforts to align local needs with national, regional, and international polices - often dictated by climate financing mechanisms and wider trends. Where the frameworks were sometimes lacking was the inclusion of traditional knowledge. The participants of the research all agreed that including traditional knowledge, and more importantly, traditional usage of marine resources, is critical for the sustainability of Samoa's indigenous fishing industry.

Views on aquaculture as an adaptation strategy were mixed. MNRE Minister Toeolesulusulu Cedric Schuster was against the idea of using aquaculture to replace/supplement marine resources citing (among other reasons) the fact that it is unlikely that aquaculture products such as limu and tilapia would be adopted as staple foods. Conversely, Chief Principal Fisheries Officer Ulusapeti Tiitii of MAF believes that aquaculture is a highly valuable initiative that provides solid adaptation solutions for Samoa's indigenous fishing industry, and that changing mindsets around the consumption of limu will allow the industry to expand. The next chapter will further discuss the results from the data collected during my fieldwork period and will provide conclusions and final thoughts on research questions one and two.

Chapter Six: Discussions and Conclusions

6.1 Introduction

Chapter six will begin by outlying a common theme raised by participants which was whether adaptation methods that value pre-existing environments should be prioritised over introduced methods that are superimposed into the environment such as aquaculture projects. This chapter will then elaborate further on the consensus responses gathered for research question one and will also provide a final discussion and conclusion on the viability of aquaculture as an adaption strategy (research question two) for climate change. An indigenous development lens will be applied throughout the discussion and will highlight the importance of indigenous knowledge and indigenous participation in climate change adaptation strategies.

6.2 Eco-system-based adaptation

Throughout the interview with Toeolesulusulu Cedric Schuster, the Minister continually referred to climate change adaptation methods that are multi-layered in nature, solutions that benefits multiple parties, especially members of the indigenous fishing community. When responding to the question *Who identifies the problems regarding climate change adaptation? How are adaptation strategies chosen/prioritized*? the Minister stated that, "*The bottom line is livelihoods*" (Toeolesulusulu Cedric Schuster, 10 October 2023). Climate change adaptation solutions "*require a combination of scientific data and the needs of people*" (Toeolesulusulu Cedric Schuster, 10 October 2023). What this could look like is adaptation methods that both protect biodiversity and meet the needs of local fishers. According to the Minister solutions such as biodiversity protection measures can "*benefit the goals of development institutions, local government, local fishers*" and of course, the local environment (Toeolesulusulu Cedric Schuster, 10 October 2023). These types of solutions are often referred to as eco-system-based adaptation (EBAs) (Mcleod et al., 2019).

Eco-system-based adaptation draw on and implant existing ecosystems into adaptation and development strategies to increase the resilience of ecosystems and communities to climate change (Mcleod et al., 2019). EBAs are typically administered through conservation, restoration, and sustainable management of ecosystems (Mcleod et al., 2019). According to Colls et al., 2009, "*recent adaptation strategies have focused on the use of technologies and climate resilient infrastructure*" but, "*there is a growing recognition for the importance of healthy eco-systems in adapting to climate change*". Healthy eco-systems provide an abundance of raw materials, are cheaper to maintain and can act as natural buffers and protection from natural disasters. As a result, EBA is readily available to rural communities and can meet the needs of the most climate-vulnerable people. Additionally, thriving ecosystems such as wetlands, mangroves and reefs can self-adapt to climate change meaning they can more easily recover from extreme weather events (Colls et al., 2009).

Examples of EBAs can be seen around the world and in the Pacific. EBA's usually consist of initiatives such as the restoration of mangrove forests, the establishment of coastal marine reserves, the preservation coral reefs and the effective management of coastal eco-systems (Colls et al., 2009). In Samoa, Nicolas Rocle explains that "*MNRE and MAF have done a lot in the way of coral reef and mangrove restoration which we (SPREP) have supported*" (Dr. Nicolas Rocle, 17 October 2023). There have also been efforts to plant corals in 6 village across the two main islands, all in conjunction with, and "*support from local villages and Matai*" (Dr. Nicolas Rocle, 17 October 2023). It could be argued that EBAs tie closely into indigenous development. In addition to meeting the needs of vulnerable communities, EBAs will often utilise TK and integrate traditional management of resources into adaptation strategies. According to Toeolesulusulu Cedric Schuster, this integration could include techniques such as banning fishing in certain areas or season to maintain fish populations (Toeolesulusulu Cedric Schuster, 10 October 2023).

Figure 6.1 A mangrove plantation in the village of Vaiusu, west of Apia.

(Source: SPREP)

EBA's clearly provide solid solutions that are in alignment with indigenous development practices. The effectiveness of EBA's raises the questions of whether EBA's should be prioritised over other adaptation strategies (such as aquaculture) that may not value, and in some cases may harm, natural ecosystems and therefore, indigenous fishing communities. If EBA's can adequately meet the needs of those most impacted by climate change, aquaculture initiatives such as the limu project could be considered redundant and potentially not viable.

All four participants agree however, that a combination of EBAs and more modern techniques such as aquaculture are necessary. When asked *Should EBA strategies (such as those in the SOS) that value existing environments be prioritized over aquaculture?* Toeolesulusulu Cedric Schuster responded that it's "*not a matter of one over the other, it's making sure that they complement one another. In areas that are overfished, or low population there needs to be a balance*" (Toeolesulusulu Cedric Schuster, 10 October 2023). Ulusapeti Tiitii agreed, "*a combination of both is necessary*" and explains that culturing systems can benefit EBAs strategies because it can alleviate the impacts of overfishing and environmental damage in coastal areas (Toeolesulusulu Cedric Schuster, 10 October 2023). Unity Roebeck believes that local environments need to be preserved but, it is possible to conduct aquaculture ventures on

a commercial scale in a sustainable fashion, reducing any negative impacts on the environment (Unity Roebeck, 12 October 2023). Unity explained further that "*aquaculture needs to be done sustainably*" and gave the example of a project restocking giant clams that only uses bio-degradable chemicals and materials (Unity Roebeck, 12 October 2023). Unity also stated that (with regard to the limu project), "*modernizing limu farming and incorporating TK will probably result in a higher yield rather than just using traditional methods but it requires a balance*" (Unity Roebeck, 12 October 2023). Nicolas Rocle, an expert in EBAs, agreed but added that "*in Samoa's case given the poor shape of coral reefs, (destroyed by cyclones and bleaching) and in terms of fish stocks, there is a need to supply fish stock whether its from aquaculture or other sources*" (Dr. Nicolas Rocle, 17 October, 2023). According to Nicolas, striking a balance is necessary and more and more of the agenda is now devoted to conserving coastal environments while also diversifying activities (Dr. Nicolas Rocle, 17 October 2023).

Linking back to research question one it is clear that EBA's play an important role in Samoa's adaptation frameworks. Many of the strategy recommendations include the preservation of coastal environments and resources which is also part of an attempt to address the needs of the indigenous fishing community.

6.3 National frameworks and the indigenous fishing community

After discussions with the participants and analysis of the source material (namely the Samoa Ocean Strategy 2020-2030) it is apparent that the policy, recommendations, and adaptation plans proposed in these national frameworks are aligned with the needs of those most impacted by climate change and environmental degradation. The disconnect between the national and local level is seemingly minimal as these tiers remain tightly interconnected through firmly entrenched systems and relationships.

As mentioned in chapter five, the participants were confident in their opinions because of the extensive measures taken to ensure the voices of villagers and coastal fishers were heard and embedded into national policy. For the SOS, years of consultation was done with local villages to identify their needs and institute adaptation measures for their individual communities. This extensive consultation period would help to ensure that national adaptation polices are addressing the impacts of climate change and environmental degradation at the grassroots level.

Although the four participants resoundingly agreed that at a planning level, national adaptation framework address the needs of the indigenous fishing industry, at an implementation level it is less clear. Unity Roebeck stated that it is hard to see evidence of climate change adaption policy implemented in the field and that the general population would be completely unaware of frameworks such as the SOS (Unity Roebeck, 12 October 2023). Discerning whether these policies are being implemented will require in-depth analysis of project reporting, which was out of scope for my research. Again, speaking to members of the indigenous fishing community would have aided me in ascertaining the level of implementation from these policies.

One illustration that the needs Samoa's indigenous fishing community are embedded into adaptation polices, is the prevalence and stressed importance of traditional knowledge (TK) within these frameworks. The SOS specifically mentions the role of TK in the protection and management of coastal marine environments (Govt. of Samoa, 2020). The SOS planned to revive TK through education models for youths. According to the SOS, by 2027 100% of students will be educated in TK and marine science education. By 2030, the SOS looks to ensure that TK is recorded, preserved and applied for activities such as resource management, seasonal calendars and weather forecasting (Govt. of Samoa, 2020).

As mentioned in 5.4, participants were asked *How important is it to incorporate traditional knowledge into adaptation strategies/solutions for Samoa's indigenous fishing industry?* Reflecting the emphasis of TK within the SOS, all four participants implored the importance of TK stating that TK should be the foundation of any framework for management. MNRE Minster Toeolesulsulu Cedric Schuster also added that traditional land usage must be also recognised when developing adaptative frameworks. All four participants stated that a merging of modern science with TK is required to produce the most suitable adaption measures for the indigenous fishing community and initiatives such as Reef Cloud, a project mentioned by Nicolas Rocle, are a step toward that partnership. This is in alignment with indigenous development scholars (Doda, 2005) who argue that, because of the complexity and centuries of knowledge underlying traditional knowledge, it can be considered as equally as important as modern scientific data (Doda, 2005).

The importance of TK in climate change adaptation and the mitigation of damage to coastal marine environments cannot be understated. The inclusion of TK within adaptation frameworks elevates the heard voices of vulnerable communities and allows the combining of TK with scientific methods to produce adaptation solutions that are best suited for specific coastal

marine environments. According to Ulusapeti Tiitii, there is a distinct lack of research on TK, especially within the field of fisheries and coastal marine management. Seeking sources of TK, especially in neglected fields such as aquaculture will be incredibly important moving forward to produce innovative adaptation solutions and maintain food security for Samoa's indigenous fishing communities.

As mentioned in chapter three, one of the key thematic areas of the SOS is the protection of Samoa's coastal environments and resources. The SOS acknowledges the importance and fragility of fringing reefs and other marine environments. The SOS also acknowledges the role of these coastal environments in providing food security and recognises aquaculture as a potential adaptative mechanism for coastal communities.

Increasingly, frameworks such as the SOS are utilising bottom-up approaches to development. These frameworks reflect a wider trend of adaptation policies looking to utilise traditional knowledge and connect with vulnerable communities to devise the most suitable adaptation strategies. This trend is reflected in the discussions I had with participants in the climate change and fisheries sector. All four participants including Ulusapeti Tiitii (who directly contributed to the SOS) agreed that these adaptation frameworks adequality address the concerns and needs of those most impacted by climate change namely, the indigenous fishing industry. Although my sample size was small, having access to sector leaders such as the Minster of Environment and Natural Resources certainly gives weight to the validity of my findings. However, speaking directly with indigenous fishers would have painted a far clearer picture of whether their needs were addressed within national adaptation policies but, due to a few limitations (see 4.5) I was unable to do so.

Because of this, I cannot definitively make a conclusion on research question one [*Is there a disconnect between Samoan national adaptation frameworks for fisheries (such as the Samoa Ocean Strategy 2020-2030) and what is needed by those most impacted (ie; the indigenous fishing industry) by climate change and environmental degradation?]* I can, however, state that from a policy perspective, a serious attempt is being made to address the needs of the indigenous fishing industry.

6.4 The future of Samoan aquaculture as an adaptation strategy

Aquaculture and the case studies of limu and Nile tilapia have proven to be a polarising subject. Aquaculture is not new to Samoa but is gaining increasing popularity particularly as more adaptation frameworks are citing aquaculture as an adaptative mechanism for climate change that can also enhance food security (2050 Strategy for the Blue Pacific Continent, 2022). The benefits of aquaculture in the context of Samoa have been previously outlined but there are a number of issues associated with the widespread adoption of aquaculture - especially in a future of climate change.

In general, the development of aquaculture initiatives faces several difficulties. Increasingly erratic rainfall patterns, intense storms, droughts, and flooding can make small pond farming (the method for culturing of Nile tilapia) impractical (Bell et al., 2011). Coastal aquaculture is also highly vulnerable to climate change impacts as infrastructure can be damaged in storms, cyclones and by rising sea levels. Warming waters, increased acidity and an increased susceptibility to disease may also discourage the development of aquaculture from both a financial and practical view (Bell et al., 2011).

Regarding specific aquaculture initiatives, limu as a viable adaptation strategy proved to be particularly divisive. MNRE Minister Toeolesulusulu Cedric Schuster believed limu cannot be widely adopted as a food source and is therefore, not a viable option for adaptation. The Minister cited several reasons, but the crux of his argument was centred around culture and tradition. Although limu is a traditional food source, he was at pains to point out that it has never been a staple food source. Limu is almost exclusively eaten on special occasions and in general, limu is only eaten by the elders at these occasions (Toeolesulusulu Cedric Schuster, 10 October 2023). Limu has never been more than a condiment comparable to the likes of horseradish or sauerkraut, participants would explain that limu is often used as a garnish for fish and pork. This could be somewhat attributed to a lack of availability, wild limu can only be found in certain coastal areas within either coral substrate or sand rubble (Fithriani, 2015). However, the Minister, Unity, and members of the Anglican church would state that limu is very salty, so much so that it would be unappetising to eat large portions of limu on a daily or even weekly basis.

To partially replace depleting coastal marine resources as a staple food source, people would have to consume a significant amount of limu. As mentioned, 100 grams of limu has a sizable amount of protein but 100 grams of limu is far larger than a typical side salad and has an extremely salty flavour. This unfavourable taste (to some) raises the question of whether it is culturally appropriate to accept limu as a staple food source. If consuming limu on a regular basis is not only against the grain of Samoan culture and society but also to detrimental to their dignity, is it appropriate to invest into this market? Could this investment instead be put toward the protection of traditional foods sourced from coastal marine environments?

The promotion of Nile tilapia as an adaption solution presented a similar, mixed story. The Minister was against the idea of mainstreaming tilapia as a food source. From a cultural standpoint, tilapia is a completely foreign species that has only been grown and consumed in Samoa over the last half century. The culturing of tilapia typically requires the construction of ponds which can be intrusive for natural environments and are obviously not tied in any way, to traditional methods of harvesting fish. Tilapia can be raised in existing lakes and ponds, but this can run the risk of destroying natural ecosystems within these environments as well as potentially destroying the ecosystems of waterway systems should tilapia escape containment. Furthermore, to make tilapia farming widely available for indigenous fishing communities, a significant number of water sources would need to either be utilised or created. Samoa has comparatively few natural water sources and constructing tens or hundreds of artificial ponds would have numerous detrimental implications (Toeolesulusulu Cedric Schuster, 10 October 2023). According to the Minister, factoring in Samoa's natural environment, tilapia culturing requires far too much freshwater and the risk of tilapia escaping into natural waterways (which was the case of the Mozambique tilapia) is significant (Toeolesulusulu Cedric Schuster, 10 October 2023).

The promotion of tilapia as a new, adaptative food source raises the same questions as limu, that is, whether the consumption of tilapia is desired and by extension, dignified. The Minister explained that tilapia has a very mud like taste and that this sentiment is share by many who try tilapia. Although the farming of tilapia has a myriad of benefits and has claimed the title of 'food fish of the 21st century' is it appropriate to promote the consumption of tilapia as an adaptative mechanism while risking environmental security and the dignity of many Samoans?

Ulusapeti Tiitii, the Chief Principal Fisheries Officer for inshore fisheries and aquaculture, had an opposing opinion and advocated for limu and tilapia. Ulusapeti highlighted the benefits of limu referencing limu's high density of essential nutrients and minerals. According to Sapeti MAF's goal is for Samoans to view limu the same way they view commonly eaten vegetables like lettuce, cabbage, and other leafy greens. The promotion of limu is also in alignment with government health campaigns such as 'slash the salt' because limu could potentially serve as a far healthier, salt replacement. Limu has also been identified as suitable diet food for the reduction of obesity, a significant problem in Samoa (Fithriani, 2015). A study conducted by Ulusapeti found that the main inhibitor preventing the general population form consuming limu was a lack of awareness around limu's health benefits and the same study found that health benefits were a top priority for younger Samoans.

Additionally, limu is relatively easy to farm on a small scale. The 2021 limu project utilised metal trays a few hundred meters from the shore that can be harvested with relative ease. Limu farming can create a new source of income for villages and provide help to bolster food security by providing a steady source of calories. Limu's benefits were externalised by the success of the 2021 limu project which saw a successful harvest and the beginning of natural limu growth as a result of the project. The farming of limu is an example of indigenous development for and by the people which utilises a marriage of indigenous techniques and modern technology. The 2021 project was a pilot, and whether limu can be farmed on a scale that is significant enough to supplement the marine protein diet remains to be seen and for now, limu remains a niche commodity.

In a similar vein to limu, Ulusapeti implored the viability of tilapia as an alternative food source. According to both Ulusapeti and Unity, if done correctly, tilapia can be harvested at a scale that could significantly bolster food security. The evidence for this is widespread. Tilapia is harvested on an industrial scale particularly in Southeast Asia and China and is well recognised as an ecologically sustainable and profitable food product (Food & Agriculture Organization, FAO, 2018). Given the right environment, tilapia can be farmed at any scale and provide subsistence and coastal fishers with an alternative source of food and income. According to Unity Roebeck, the environmental risks of tilapia are minimal as-long-as sustainable management techniques such as water and fertiliser recycling systems can be utilised (Unity Roebeck, 12 October 2023). However, tilapias' potential as an alternative food source is still hindered by the fact that it is not culturally or socially accepted in Samoa as a

food fish. Where tilapia has been heavily adopted is in countries where tilapia fits seamlessly into existing cuisine and diets but there are several factors preventing the same from occurring in Samoa.

To conclude on the viability of aquaculture in Samoa, for the case studies of limu and tilapia the answer is unclear. While aquaculture has been numerously cited as an adaptative mechanism for climate change across the Pacific, it is not a one size fits all solution. Furthermore, regardless of precautionary measures, in Samoa, both limu and tilapia culturing sites are at risk of damage from the impacts of climate change. Limu is grown in shallow waters, easily susceptible to damage from cyclones and storms and the same goes for tilapia culturing infrastructure which can be destroyed by extreme weather. Both cases also have the issue of taste and are not preferred or accepted by many Samoans often because of their unfamiliar and unfavourable flavour. Because tilapia is regarded as incredibly resilient to varied environmental conditions (including extreme heat) and can provide a large amount of protein and calories within a short period, the freshwater fish is arguably the more feasible adaptation option of the two case studies. For the indigenous fishing industry, provided the environmental circumstances are suitable, aquaculture could be a viable option as a small-scale niche commodity that can provide some income and calories. On a larger scale it is difficult to state whether aquaculture produce can replace the typical diet and mitigate depleting sources of coastal marine species.

6.5 Too little too late for EBA's?

As mentioned in 6.2, each participant would cite eco system-based adaptation as a promising adaption option for Samoan fisheries both commercial and coastal. EBA's not only protect existing environments but serve as multifaceted solutions for climate change. For example, newly allocated marine reserves can protect vulnerable coastal marine environments, provide more fish for surrounding communities due to overspill, and serve as an eco-tourism destination (Toeolesulusulu Cedric Schuster, 10 October 2023). The Savaia giant clam farm is an example of this where the marine environment is protected, an overspill of clams into the surrounding areas provide food for villagers and villagers earn income through tourism. Protecting coral reefs, limiting overfishing, regenerating mangrove ecosystems and many other

forms of EBAs will go a long way to protecting and ensuring the sustainability of coastal marine resources (Toeolesulusulu Cedric Schuster, 10 October 2023).

If EBA's seemingly provide a perfect adaptation solution, why look at aquaculture initiatives at all? Nicolas Rocle, an EBA expert, explained that given the state of Samoa's coral reefs, the state of fish stocks and marine health in general, it is important to explore aquaculture activities such as limu and tilapia farming (Dr. Nicolas Rocle, 17 October 2023). EBA projects are also vulnerable to the impacts of climate change and the protection of coral reefs means nothing for fish populations if those reefs bleach and are destroyed. The fourth global bleaching event which is predicted to hit the southern hemisphere this year will undoubtably have a significant impact of Samoa's reef systems (Hess, 2024). Nicolas explained that there are extremely limited options for preventing bleaching and suggested strategies such as shading for reefs can be impractical. The Minister and Unity Roebeck would also add that less people are partaking in coastal fishing. In the Ministers home village of Satapuala, the construction of the airport has forced his village inland and the village once heavily involved in fishing, now has only a few remaining coastal fishers (Toeolesulusulu Cedric Schuster, 10 October 2023). Clearly, the need for aquaculture activities in Samoa is not unfounded, and a continuation of both EBA and aquaculture initiatives will likely be needed to ensure the sustainability of coastal marine resources and by extension, the wellbeing of the indigenous fishing community.

6.7 Concluding summary.

To conclude, Samoa's coastal marine environments and those who rely upon the resources dwelling within them, are in an increasingly vulnerable position. Climate change and environmental degradation are rapidly degrading the health and population of marine environments and marine species, the latter of which are being depleted at an alarming rate. Samoa has produced frameworks to adapt to these rapid changes and for the most part, these frameworks are adequately meeting the needs of the indigenous fishing industry who bear the brunt of climate change and negative environmental impacts.

Within climate change adaptation frameworks such as the 2050 Strategy for the Blue Pacific Continent and the Samoa Ocean Strategy 2020-2030, aquaculture is often recommended as an adaptative mechanism for climate change. This research found that while they hold promise as adaptation mechanisms particular in the face of food insecurity, it is unlikely that aquaculture

initiatives in Samoa such as the culturing of limu and Nile tilapia can serve as viable adaptation options for the indigenous fishing industry of Samoa in the long term. A combination of aquaculture initiatives, ecosystem-based adaptation and other strategies recommended by regional and national frameworks are needed to ensure the sustainability of Samoa's coastal marine environments and resources in the face of climate change and environmental degradation.

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Appendices

MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND

20/09/2023

Dear: Louis Morrell

Re: Low Risk Notification - 4000028184 - An investigation into the strategies employed by Samoa's Indigenous fishing industry to manage and mitigate the adverse impacts of climate change.

Thank you for your notification which you have assessed as Low Risk.

Your project has been recorded in our database for inclusion in the Annual Report of the Massey University Human Ethics Committee.

The low risk notification for this project is valid for a maximum of three years.

If situations subsequently occur which cause you to reconsider your ethical analysis, please contact a Research Ethics Administrator.

Please note that travel undertaken by students must be approved by the supervisor and the relevant Pro Vice-Chancellor and be in accordance with the Policy and Procedures for Course-Related Student Travel Overseas. In addition, the supervisor must advise the University's Insurance Officer.

A reminder to include the following statement on all public documents:

"This project has been evaluated by peer review and judged to be low risk. Consequently, it has not been reviewed by one of the University's Human Ethics Committees. The researcher(s) named in this document are responsible for the ethical conduct of this research.

If you have any concerns about the conduct of this research that you want to raise with someone other than the researcher(s), please contact Professor Craig Johnson, Director - Ethics, telephone 06 3569099 ext 85271, email humanethics@massey.ac.nz."

Please note, if a sponsoring organisation, funding authority or a journal in which you wish to publish requires evidence of committee approval (with an approval number), you will have to complete the application form again, answering "yes" to the publication question to provide more information for one of the University's Human Ethics Committees. You should also note that such an approval can only be provided prior to the commencement of the research.

Yours sincerely

Professor Craig Johnson
Chair, Human Ethics Chairs' Committee and Director (Research Ethics)

MASSEY UNIVERSITY
COLLEGE OF HUMANITIES
AND SOCIAL SCIENCES
TE KURA PŪKENGA TANGATA

An investigation into the strategies employed by Samoa's Indigenous fishing industry to manage and mitigate the adverse impacts of climate change.

INFORMATION SHEET

Introduction

This research asks the following questions:

.1. What strategies are being employed in Samoa's Indigenous fishing industry to adapt to climate change and environmental degradation?

2. Is there a disconnect between the institutional adaptation strategies for Samoa's indigenous industry and what is needed at a local level and by those most affected by climate change?

3. Is aquaculture a viable adaptation strategy for Samoa's indigenous fishing industry?

This research is being conducted by an International Development Master's student from Massey University, Aotearoa New Zealand. I, Isabella Louis, hold the following qualification: a Bachelor's degree in International relations and development. My supervisor (Prof. Glenn Banks) have significant experience in doing research in the Pacific that has benefited Pacific communities

Project Description

My research aims to examine the strategies used by Samoa's indigenous fishing industry to combat the adverse impacts of climate change and explore the viability of aquaculture as an adaptation strategy. Through an alternative development lens, I will explore the institutional responses to the impacts of climate change on Samoa's indigenous fishing industry and will attempt to discern whether there is a disconnect between the institutional policies and what is needed at the local level. I will also be investigating the use of aquaculture as an adaptation strategy. In particular, my research will centre on recent efforts to revitalize Samoa's limu (seaweed) industry and whether the industry can provide a viable adaptation solution.

MASSEY UNIVERSITY
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AND SOCIAL SCIENCES
TE KURA PUKENGA TANGATA

Invitation

I am inviting you to participate as I would value drawing on your experience and insights to help build an understanding of Samoa's indigenous fishing industry and the institutional response implemented to combat the adverse effects of climate change and environmental degradation on the sector.

You have been selected to participate in either:

- a key informant interview (30 minutes-1 hour) or,
- active participant in the fishing community

Data Management

The information you provide will be kept confidential and stored safely. All data, including interview recordings and notes, will be stored in the research project's password-protected iCloud system.

Participant's Rights

We would be delighted if you agreed to participate, but please be assured that you are under no obligation to do so. If you decide to participate, you have the right to:

- *decline to answer any particular question;*
- *withdraw from the study at any time;*
- *ask any questions about the study at any time during participation;*
- *provide information on the understanding that your name will not be used unless you give permission to the researcher;*
- *be given access to a summary of the project findings when it is concluded.*
- *ask for the recorder to be turned off at any time during the interview.*

Project Contacts

If you have any questions about this research please contact the following investigators:

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G.A.Banks@massey.ac.nz

Committee Approval Statement

This project has been evaluated by peer review and judged to be low risk. The Ethics Notification Number is: 4000028184. Consequently, it has not been reviewed by one of the University's Human Ethics Committees. The researcher named in this document is responsible for the ethical conduct of this research. If you have any concerns about the conduct of this research that you want to raise with someone other than the researcher(s), please contact Professor Craig Johnson, Director (Research Ethics), email humanethics@massey.ac.nz